POWER

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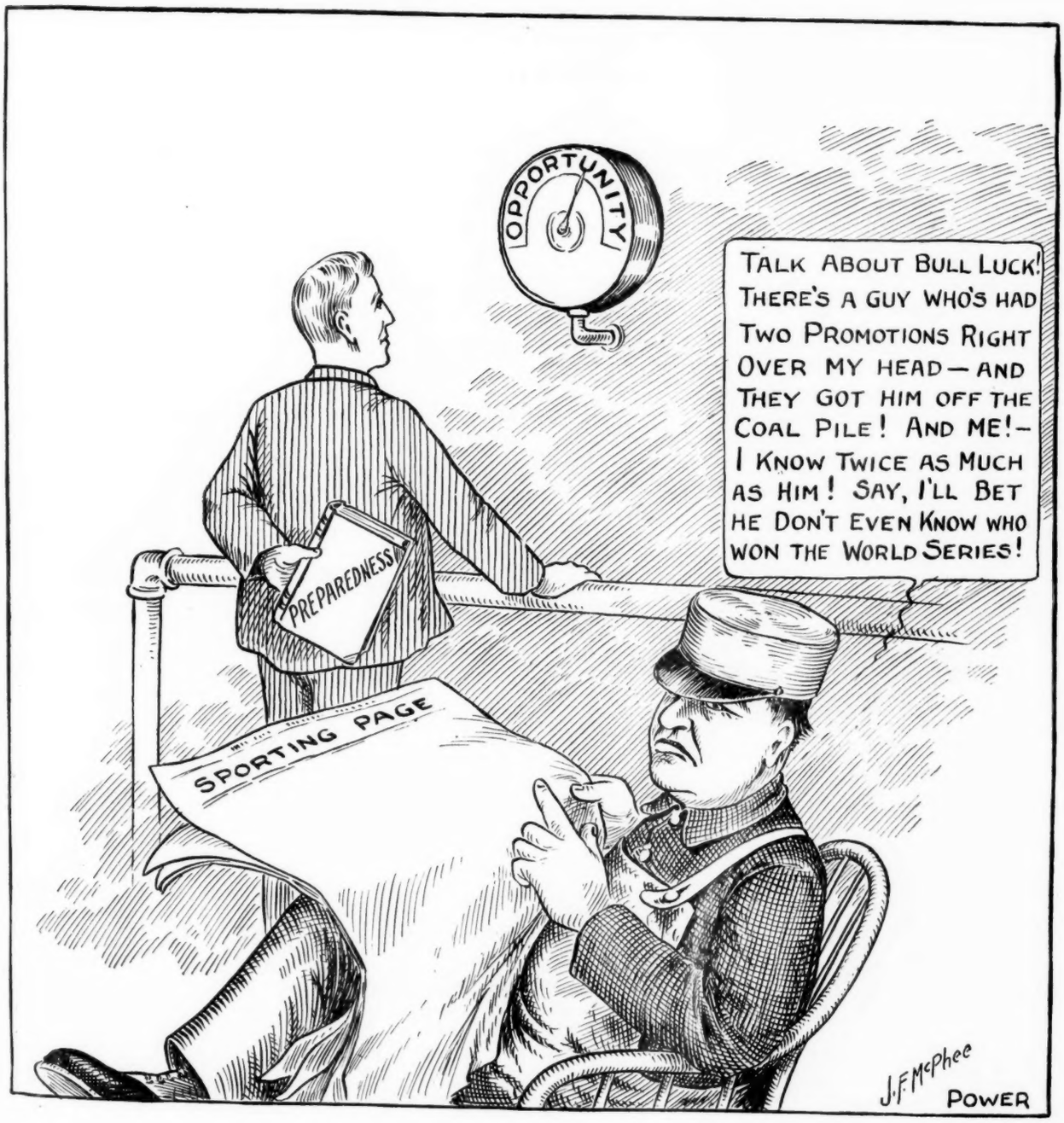
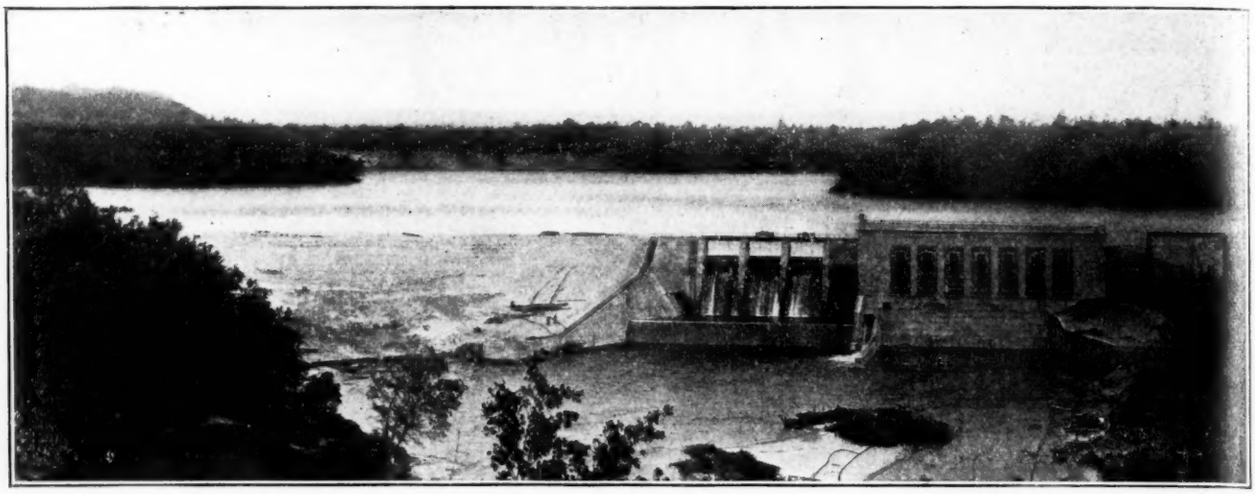
Why Some Engineers Are More Stationary Than Others


OPPORTUNITY
TALK ABOUT BULL LUCK! THERE'S A GUY WHO'S HAD TWO PROMOTIONS RIGHT OVER MY HEAD — AND THEY GOT HIM OFF THE COAL PILE! AND ME! — I KNOW TWICE AS MUCH AS HIM! SAY, I'LL BET HE DON'T EVEN KNOW WHO WON THE WORLD SERIES!
PREPAREDNESS
SPORTING PAGE
J.F.McPhee
POWER



Junction Development Power Plant*

This is the largest hydro-electric plant in Michigan. The dam, with a 51-ft. head, rests on an earth foundation. A tumbling-bay is employed to prevent erosion of the river bed by the water passing over the dam. Electrically the plant is of simple construction. Its rated capacity is 16,500 kw. It is connected with Grand Rapids by a 140,000-volt line.

THE Consumers' Power Co., which operates a large interconnected electric-service system in the lower peninsula of Michigan, has recently completed the largest hydro-electric plant in that state. It is situated on the Manistee River about 35 miles from Wellston and is called Junction Development, since a river known as the South Branch joins the Manistee near the site. The plant, which is rated at 16,500 kw., is being operated in parallel with the rest of the company's system as a peak plant, a 140,000-volt transmission line connecting it with Grand Rapids, 95 miles away, while other lower-voltage lines join it with nearer places. In general the plant will utilize all of the flow of the river, although the capacity of the pond, which covers 1560 acres, permits considerable flexibility. The plant will be used to meet the requirements of the 30-cycle system (the part south and east of Grand Rapids operating at 60 cycles), so that no definite daily program of operation may be expected. However, it will usually be possible to avoid wasting any water over the spillway.

Among the hydraulic features of the plant are the following: The head is 51 ft., which is an unusual height for a dam resting on an earth foundation. The flow of the Manistee River is remarkably uniform, the extreme flood being only about four times the ordinary low-water flow. The 452,500 cu.yd. of sand in the embankment which comprises part of the dam was deposited by a sluicing process during the winter of 1917-18 with very satisfactory results as to water-tightness and settlement, the seepage being only 0.46 cu.ft. per second and practically constant for two months. Special hydraulic joints are used in the various structures, and provision is made to prevent the gates freezing fast in any position. The dam construction employed to prevent erosion of the river bed by the water tumbling over the dam, and for other reasons, is also interesting.

Electrically, the plant is about as simple as could be imagined, this being a feature that dates back to the beginning of the system. It will probably be remembered that this system was one of the first (under a different name at that time) to attempt real high-voltage transmission (110,000 volts) and that oil switches, lightning arresters and insulators suitable for 110,000 volts were hardly known at the time. The interior of the station contains little more than the generators and the low-voltage oil switches, the cables running to outdoor equipment including 140,000-volt transformers, aluminum-cell lightning arresters and oil switches controlled from within the station. Having relatively small rating compared with some hydro-electric plants in the West and being tied in with the rest of the system by long transmission lines that act as dampers to any surges that may occur, the station has no elaborate protective equipment in the form of relays, reactors, etc.

Two conditions made it particularly desirable to locate a station at the site chosen. One was that the Manistee River valley in general is broad, while here was a narrow part across which a dam could be easily erected. Secondly, this site is the farthest downstream where a clay bottom exists and at which a dam of reasonable height would back up the water to the next good site above.

Within the last fourteen years the owners and designing engineers of this development have built several other successful dams upon similar clay hardpan foundations with heads ranging from 26 ft. to 40 ft. on the Au Sable, Muskegon and Grand Rivers in Michigan. Where the hardpan is compact and continuous no round or sheet piling has been used. At Junction Dam a line of sheet piling extends across the valley and to a depth of about 40 ft. below normal river surface.

The watershed above Junction Dam is 1451 square miles, and at its maximum elevation Junction Pond has an area of 1560 acres. The dam backs up the water

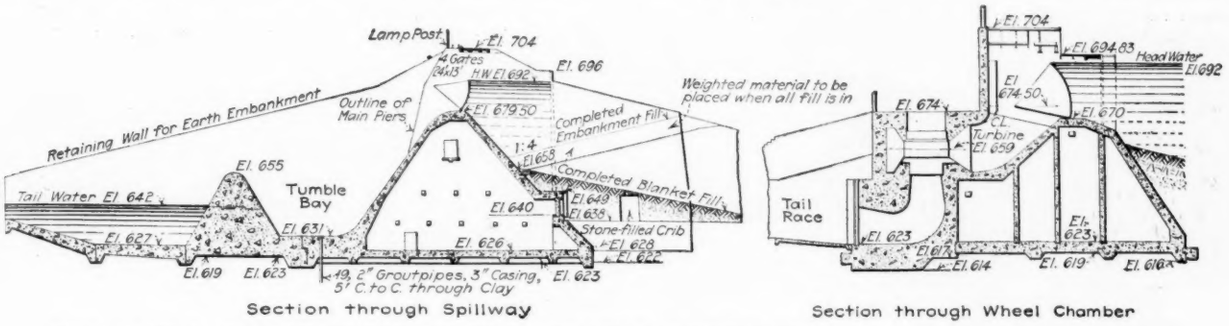
*From the "Electrical World."

in the main river about 8 miles, and in the South Branch, which enters 1.5 miles above the dam, a total distance of about 4.5 miles to the Stronach Development built in 1912 by the same owners. Stronach Development was built primarily to furnish power for the construction of the larger dam and contains two 400-kw. 7500-volt 30-cycle generators, which feed into a transmission line operating at 40,000 volts and extending from Manistee to Cadillac, a distance of 50 miles. A 7500-volt line extends to Junction Development.

The Junction power house and spillway were placed immediately in the old river channel, the river having been diverted during construction. The power house is 145.5 ft. in length and 40 ft. in width. Beyond this is the spillway, consisting of four motor-operated 24 x 13-ft. steel Tainter gates surmounting a hollow concrete structure.

The ordinary flood is about 5000 cu.ft. per sec., and the maximum flood on record for the past twenty years is 7500 cu.ft. per sec. Two of the gates will, therefore, safely discharge the maximum flood on record without causing rise of headwater. The freeboard on the embankment is 12 ft. to provide for the possible failure of any future dam upstream.

Water passing through the Tainter gates is received in a tumble bay 24 ft. deep, formed by a solid concrete weir of this height across the spilling channel, the crest of this weir being 13 ft. above tailwater. The spill-



FIGS. 1 AND 2. SECTION OF DAM THROUGH SPILLWAY, SHOWING TUMBLE-BAY AND SECTION THROUGH THE WATER-WHEEL CHAMBER

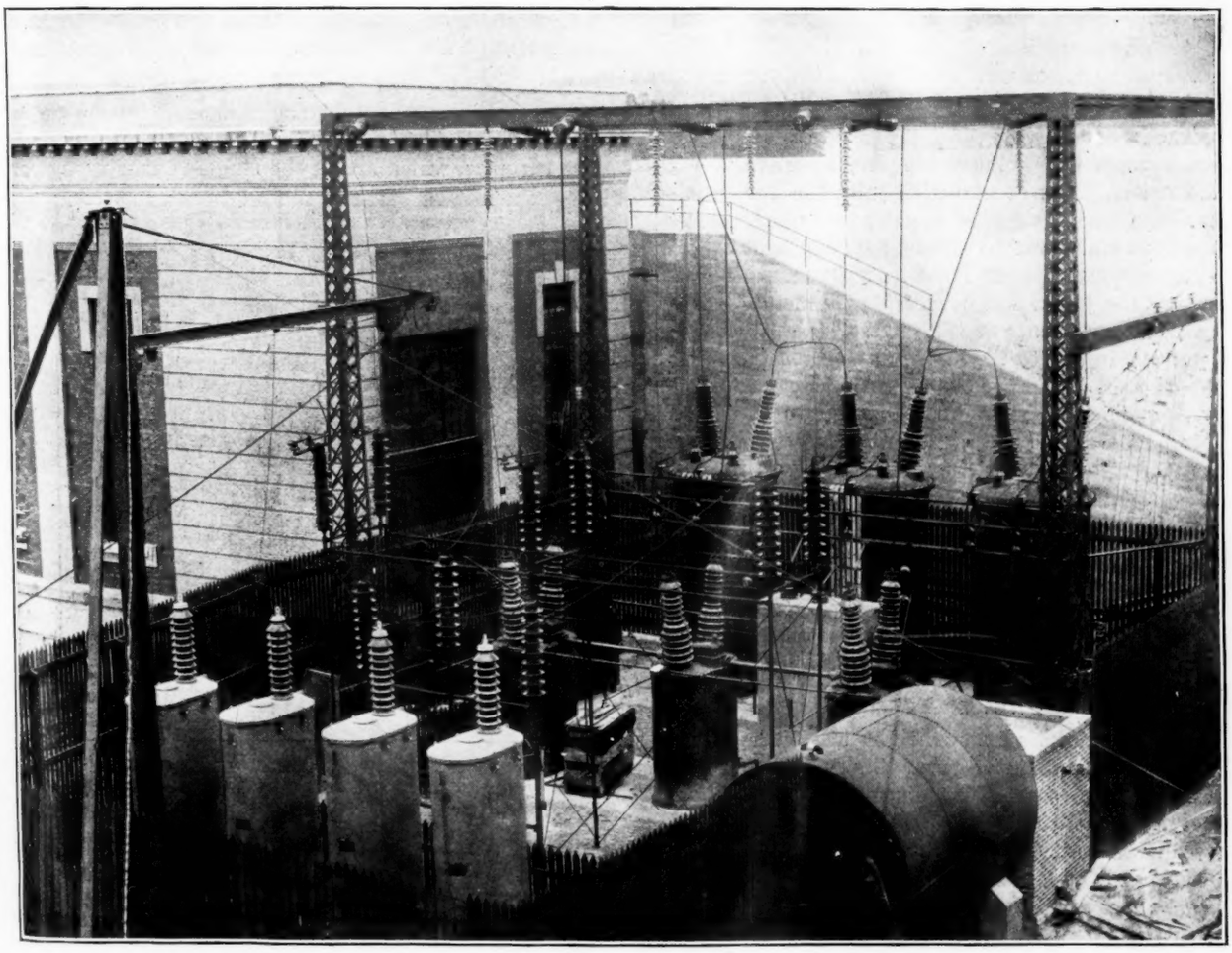


FIG. 3. TRANSFORMING, SWITCHING AND LIGHTING-ARRESTER EQUIPMENT CONNECTED WITH 140,000-VOLT LINE

way operates successfully to deliver the water at low velocity. In passing 5000 cu.ft. per sec. through the spillway sand lies undisturbed on the last 50 ft. of concrete apron.

Special attention had to be given to the design and construction of joints in the power-house structure to prevent leakage from water. A total head of 42 ft. exists at the wheel pit. Below this level the greater

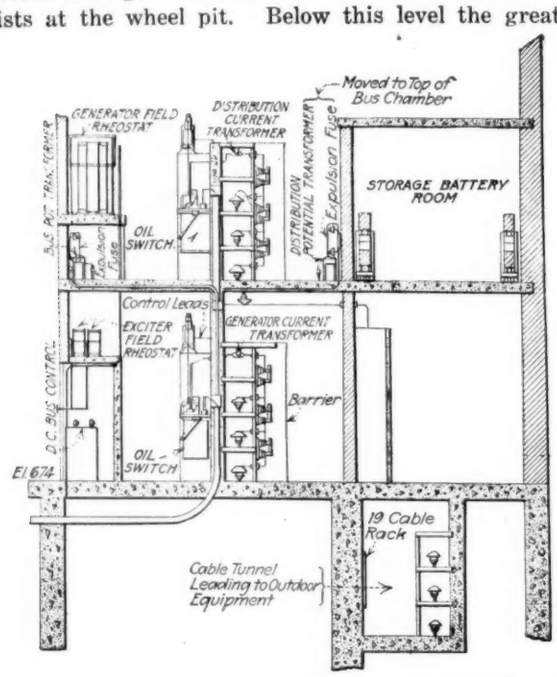


FIG. 4. DETAILS OF BUS AND SWITCH STRUCTURE WITH CABLE TUNNEL LEADING TO OUTDOOR EQUIPMENT

thickness of concrete and the absence of necessary joints, made the problem simpler, although a higher head exists. The construction joints in the penstocks have been made as few as possible and where necessary have been made water-tight by specially bent copper or corrugated galvanized ingot-iron strips, these strips crossing the joints and permitting by their special corrugations movements at the joint. With sufficient care to prevent injury to the strips during construction this type of joint has proved quite satisfactory after using for a number of years in heads up to 60 ft. This type of joint is also used at intervals in the embankment core walls, the water-tightness of which is in a great measure due to the care taken with the joints. Construction plans were prepared in detail, indicating exactly where joints were allowed, and no departure from this joint program was permitted without thorough consideration by the designing engineers. The maximum length cast without joints was 114 ft. for the downstream wall of the three penstocks.

Steam-Heated Tainter Gates

Aside from the greater height at which the gates are set, the four-Tainter-gate spillway at Junction Dam does not differ essentially from numerous similar spillways built in various parts of America. However, the severe winter conditions of this locality require that one of the spillway gates be provided with a heating system so that there will be no delay in opening a gate. When one of the gates has been opened and water allowed to flow for a few hours, the circulation will thaw the ice on the remaining gates. The scheme of heating is to warm an inclosed chamber between the gate piers, having such shape and size as to permit the opening of the gate within the chamber. The steam radiators are supported on the upper radial struts of the gate and swing with it, the connection to the steam main being by a 2-in. flexible hose. Steam is supplied from the low-pressure boiler of the power-plant heating system.

This foregoing method of heating has the advantage of applying heat directly to the surface of headwater about 2 ft. in width between the curtain wall and the gate itself. The details used would not be applicable to a dam at which the headwater was allowed to rise above a fixed elevation, but at this plant the uniform flow of the Manistee River permits maintaining the headwater at a constant elevation.

Each of the three wheel chambers is closed by a steel Tainter headgate 30 ft. wide by 22 ft. in vertical height. Like the spillway Tainter gates, these headgates are hoisted directly by motor-driven worm-geared hoists without the aid of any counterweights. The hoists are operated from the power-house switchboard, where telltales in sight of the operator indicate the position of the gate. Owing to the large size of these headgates the water can pass at a velocity of 2.57 ft. per sec. From the racks to the turbines the form of the water passages is such that the water moves very smoothly, making it possible to use turbine current meters very successfully for measuring waterwheel efficiencies. For making such tests the current meter sections are taken 4 ft. downstream from the racks at the headwater level, the vertical being 10 ft. from the racks at the bottom.

How Sizes of Units Were Chosen

The entire rating of the power house is now provided for by three vertical direct-connected generating units. The turbines, which are of the single-runner type, were

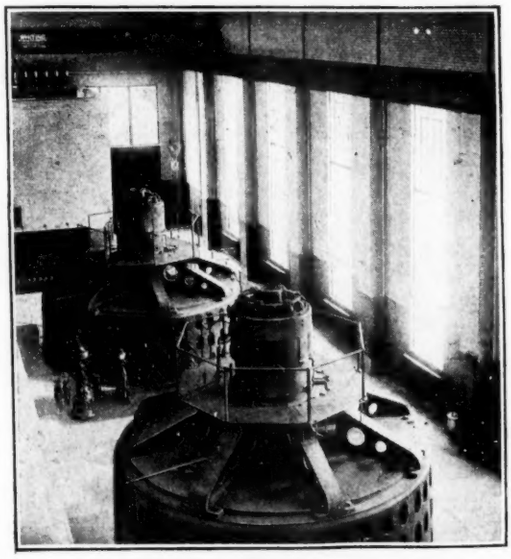


FIG. 5. TWO 5500-KW. WATERWHEEL GENERATORS; SWITCHBOARD IS IN BACKGROUND AGAINST WALL OF BUS AND SWITCH COMPARTMENT

built by the Wellman-Seaver-Morgan Co. At 47-ft. working head and when all three units are running full load 1700 cu.ft. per sec. of water is used per unit. With the size of units chosen one of the three turbines will utilize the entire flow of the river at low water, and the three will take care of the ordinary flood flow.

Although the guaranteed efficiency of the waterwheels is 88 per cent. maximum, careful field efficiency tests indicated that they exceed this amount by 4 per cent. A very flat curve was obtained, the efficiency of the generators being 96.7 per cent. maximum and 96.5 per cent. at full load. From 0.4 load to full load the waterwheels show an efficiency above 80 per cent. No shops tests were made, owing to war conditions; that is, the shops were so crowded that time could not be taken to make tests.

The generators, which are rated at 5500 kw., 30-cycle and 75 r.p.m., and all electrical equipment were furnished by the Westinghouse Electric and Manufacturing Co. The rotor spiders are cast steel and guaranteed to stand 100 per cent. overspeed. The flywheel effect is 3,400,000 ft.-lb. at 1 ft. radius. A frequency of 30 cycles was selected because that is the periodicity in the northwest portion of Michigan, although 60 cycles is the frequency of all plants of the Consumers' Power Co. south and east of Grand Rapids.

On top of each generator is a Kingsbury thrust bearing, which supports the rotating elements of both generator and turbine. On the shaft above the thrust bearing is a direct-connected compound-wound exciter rated at 55 kw. and 250 volts. The speed of the units is controlled by Lombard hydraulic governors, each having a capacity of 60,000 ft.-lb. The actuators are of a special new type operated by oil pressure, both for direct application and through the hand control directly from the actuator as well as on a separate stand. A central oil-pressure system is used, two pumps being provided, either of which is sufficient for the three units. For filtering the oil used for this purpose as well as for lubrication, Richardson-Phenix equipment rated at 100 gal. to 200 gal. per hour is provided. Keeping oil clean and conserving oil are considered so important by the engineers connected with this development that they even go so far as to say that all large water and steam power plants should have adequate oil-filter systems. The system mentioned has been quite satisfactory in other plants which the same engineers have designed.

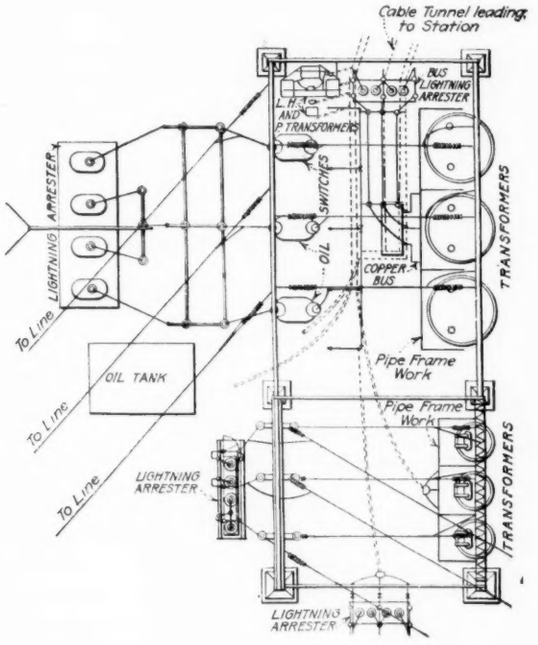
The power house is served by a 30-ton Whiting crane, which can be used at 50 per cent. overload for occasional handling of the generator rotors. The heaviest parts of the transformers are lighter than the rotors.

Switching and Bus Layout To Save Expensive Building Construction

At the shore end of the power house is an inclosure, on the first floor of which, immediately back of the switchboard, are the generator-bus and oil-switch compartments. Back of these against the outside wall of the building is a small shop for repair work. Over the shop on the second floor is a storage-battery room, and next to it are the distribution bus and switch compartments and generator-field rheostats. The switchboard, which, as mentioned before, is at the end of the generator room, is made up of ten panels, of which two are for future equipment.

The exciter rheostats are hand-operated and are situated on a platform to the rear of and immediately above the switchboard. The generator-field rheostats are motor-operated and are on an elevated platform on the second floor, above the switchboard. The storage battery, which is used only for energizing control circuits, consists of sixty cells rated at 112.5 amp.-hr. It is charged by a 2.25-kw. motor-generator set, the control panel of which is on the main floor to the right of the switchboard.

The entire layout of the station switchboard and switching apparatus was arranged principally to save space and to avoid the unnecessary expense of enlarging the power house on the downstream side, where to support it over the tailrace would be expensive. With



Plan

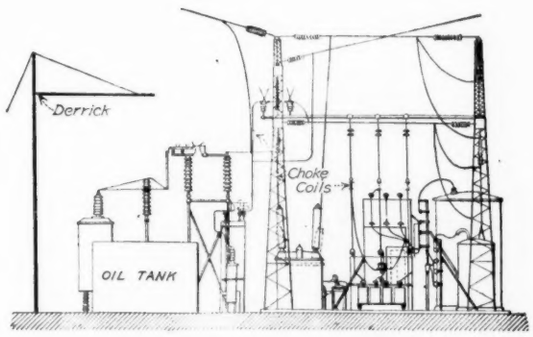


FIG. 6. ULTIMATE LAYOUT OF OUTDOOR EQUIPMENT, SHOWING DERRICK FOR HANDLING ARRESTER CONES

but three units it was entirely feasible to install the switchboard at the end of the station and still provide an ample passageway to the main entrance without unduly widening the power house.

All cables are carried in wrought-iron pipe conduits placed mostly in the concrete floors and walls. From the main generator to the oil switches the circuits are 500,000-circ.mil lead-covered cables. The switches are solenoid-operated 7500-volt, 600-amp. units. Cables run from these through the wall in the rear to current transformers mounted vertically and thence to "disconnects" and the main busses. The busses are separated by freestone barriers, these being used in place of con-

crete or "asbestocel," as they are cheaper and at the same time fully as satisfactory if not more so. Usually, thin concrete work, the engineers believe, is much more expensive to build and finish in an attractive manner than is figured in the drafting room. The generator-bus potential transformers are located on the second floor, above the switchboard.

Various circuits are taken off from the generator busses through "disconnects" and current transformers to solenoid-operated oil switches, which are immediately above the generator bus. The distribution potential transformers are above the busbar compartment. The circuits extend from their respective oil switches to a concrete subway running from the basement of the power house to an outdoor substation. This subway is 6 ft. wide by 9 ft. high. On one side are compartments with freestone barriers for 7500-volt circuits, 2000-amp. feeding the Croton-Grand Rapids 7500/140,000-volt transformers. On the other side are cable racks for other circuits which are carried in fiber conduit.

All High-Tension Apparatus Out of Doors

The outdoor substation is situated to the landward and partly downstream from the generator house on the same level as the main floor. Here are installed three delta-connected 5000-kv.-a. 140,000/7500-volt 30-cycle single-phase, oil-insulated, water-cooled transformers. On each transformer are 120,000-volt to 140,000-volt taps arranged in 5000-volt steps. This is in accord with the standard transformer specifications of the Consumers' Power Co., which are made essential by the fact that it is sometimes necessary to adjust voltages in order to secure best results in delivery of energy. "Disconnects" are placed at transformers in the 7500-volt leads.

The transformers are mounted on trucks supported in slightly elevated concrete platforms. To permit repairing and inspecting the transformers without exposing them to the weather a transfer-lorry track is provided between the substation and the power house. In the latter is a pit into which a transformer may be lowered before removing the core. With this arrangement extra headroom is not necessary.

None of the recent large stations of the Consumers' Power Co. has a spare transformer. When repairs are made, it is the custom to operate the transformers in open delta, readily separable joints being provided to permit their disconnection. All high-tension busses consist of galvanized-iron pipe mounted on a galvanized-steel structure with strain insulators for supports.

The 140,000-volt oil switches, 300-amp. units, are non-automatic, solenoid-operated and are set on concrete foundations. Automatic switches are undesirable in this case because the Consumers' Power Co. employs the load dispatcher method of operating its plants. However, the generator switches become automatic during the process of synchronizing on the insertion of synchronizing plugs. The 140,000-volt electrolytic lightning arresters with their horn-gap structure are set on concrete foundations and are served by a cone-stack derrick. Provision has been made for future extension of the outdoor substation to take care of a 40,000-volt Manistee-Stronach-Cadillac transmission line.

The transformer cooling water is provided by a 2-in. centrifugal pump having a capacity of 125 gal. per min. It is directly connected to a 5-hp. motor installed in the machine shop and takes water from the penstocks. All piping to and from the transformers is laid in concrete trenches where necessary and is covered to prevent freezing. The transformer cooling-water indicator is a cast iron box with a water-tight glass cover. In it are electrical contacts connected with a bell alarm.

Oil for the transformers and oil switches can be supplied by a 1.5-in. centrifugal pump having a capacity of 70 gal. per min., directly connected to a 5-hp. motor. It is connected with a storage tank holding 8800 gal., and the pipes and valves are so arranged that oil can be pumped into the transformers or oil switches from the storage tank or oil barrels, or vice versa. All of this equipment is installed in the outdoor substation. A portable oil-filter press with a transformer attached is available and is used at other plants in the system. Three 25-kv.-a. 7500/220-volt 30-cycle single-phase transformers are also installed in the outdoor substation to supply power for small station auxiliaries and local lighting.

Organization and Method of Operation

Junction Dam was built by the Consumers' Power Co. with its own forces and equipment. This company is a subsidiary of the Commonwealth Power, Railway and Light Co., which is managed by Hodenpyl, Hardy & Co., of New York and E. W. Clark & Co., of Philadelphia. B. C. Cobb, vice president of Hodenpyl, Hardy & Co., is president of the Consumers' Power Co. and represented these companies in connection with this work; Frank Silliman, Jr., of E. W. Clark & Co., represented that company. J. B. Foote, chief engineer of the Consumers' Power Co., was in general charge of the design and construction of this plant. G. S. Cochran was general construction superintendent, and the resident superintendent was Fred B. Taylor. George F. Stecker was in charge of the electrical part of the design and construction. The hydraulic and structural design and engineering supervision of construction, except for electrical features, was in charge of the Fargo Engineering Co., of Jackson, Mich., H. N. Tuley, resident engineer.

Saving by Lightless Nights

A special to the New York *Times* says: The Fuel Administration announced today (Aug. 3) that records kept by its experts showed that a saving of more than 60,000 kilowatt-hours, which is equal to 100 tons of coal, was made on the first of the "lightless nights" in the Borough of Manhattan. This saving, it was estimated, would be much greater during the winter months.

The figures collected, the statement said, indicate a coal economy through the "lightless nights" of 40,000 tons a year in Manhattan alone. The national saving is estimated at "more than 1,000,000 tons of coal a year."

If the lamps used for the signs and suppressed illumination average 20 watts, a kilowatt will run 50 of them if applied at the lamps or 40 of them with a loss of 20 per cent. between the station and the lamps. The 60,000 kw. would run 2,400,000 of them one hour or 400,000 of them six hours on an average.

This looks like a good many, but there are 15,000 in one chewing-gum sign alone.

Some Features of Low-Compression Oil Engines—III

By L. H. MORRISON

The present article discusses types of frames and bearings commonly found in low-compression oil engines of the two-stroke-cycle type and gives suggestions concerning lubrication.

IN THE matter of frame design each engine builder has followed his own ideas; as a result hardly two engines use the same design of frame. However, all may be separated into two types—the open and the inclosed.

Many engines of the horizontal two-stroke-cycle type have frames entirely inclosed, and access to the interior parts is had only by removing the air check valve and suction pipe. In an engine of this design the engineer should not neglect to inspect the connecting-rod bearings simply because they are hard to get at. Even though it does involve considerable effort, the air valve should be removed at least monthly and the crank box tested for wear. Care should be taken that this box does not have too much side play. There is a tendency at all times for this bearing to wear unevenly, allowing the rod to get out of line. Frequently, this will cause cylinder scoring. It is more likely to happen in the inclosed engine if the engineer is lax in his inspection.

Crank Case Must Be Free of Excess Oil

Another detail of importance in the horizontal engine is the necessity of keeping the crank case free from excess oil. It is noticeable that many engineers are careless in this matter and allow the oil to accumulate until the crank strikes the oil surface. This, of course, causes the oil to splash into the piston. This oil may strike the hot piston head, carbonize and adhere in a thick coat or scale. Means of removing the heat from the piston head is poor at best, and scale is a poor conductor of heat. Therefore it is likely to contribute to a fractured head. Furthermore, part of the oil will splash upon the cylinder walls. There is no way to drain this away in a horizontal engine; it will carbonize on the cylinder walls. This may result in a cut piston or badly gummed piston rings.

The air suction valve is a frequent source of trouble. This valve, when made of leather, and after being in use for some time, will have a tendency to cup and partly pull through the valve seat. Where the crank case is not kept drained of oil, the breathing action of the valve causes the leather to become saturated with oil, rapidly destroying the valve. The best leather to use for the valve is an acid oilproof leather-belting stock.

Frequently, the air valve is noisy in action. This, ordinarily, is due to its having too great a lift. The remedy is to cut off part of the valve guard, thereby reducing the lift. In those engines where the air valve is a brass poppet type with a rubber ring on the valve seat and a spring to cause the valve to seat quickly, the noise is usually not great. In cases where it is objectionable, it is better to increase the thickness of the rubber ring, thus decreasing the valve lift, rather than change the spring tension. If the springs be weakened, the time interval of closing is increased, thus reducing the compressor efficiency.

It is well to remember that it is impossible to make the suction noiseless as long as there is no muffler on the air suction line. Some engines arrange a muffler effect by drawing the air from the hollow engine subbase. In these cases the air usually passes across the top of the foundation and below the oil pan. There is a tendency in such a construction for the current of air to pick up any particles of cement that are on the surface of the foundation. To safeguard this, on erection of the engine a couple of gallons of linseed oil should be poured on the foundation surface. This makes a dustproof seal that will eliminate the trouble.

Air valves, of all types, require replacement when the wear allows the air to leak through. This air leakage reduces the amount of scavenging air and its pressure, which is seldom more than three pounds gage, and if reduced but a slight amount, will be insufficient to completely scavenge the cylinder of the exhaust gases. This means loss of power and a decidedly smoky exhaust—and often increased fuel consumption.

Some engines make use of a piston air valve. This should last for years before replacement; but it demands oiling. It has the further advantage of being very quiet in action, because of the large port opening for a small valve travel.

Prevention of Air Leaks Along Shaft

Any inclosed crank-case engine must have some means of preventing the air from blowing out along the shaft. Some builders make use of a stuffing-box arrangement at the outer end of the main bearings. With this design the bearing cap must make an air-tight joint with the lower part of the bearing or housing. It is better, in case of renewing the shims, to use either paper or a thin rubber packing. It is well-nigh impossible to secure air-tightness when using copper or tin shims.

In replacing the stuffing-box, square duck packing or braided hemp well soaked in oil and graphite is excellent. In drawing up the gland it is not necessary to exert much pressure; the two or three pounds air pressure does not require much gland pressure. If the gland is drawn up tight, a groove will gradually develop on the shaft.

A few engines are equipped with an air-sealing device at the inner face of the main bearing. This is usually in the form of a brass plate placed between the crank web and the main bearing. It has a close fit with the shaft and, if provided with springs to keep it against the bearing, will prove effective. The objection to this device is that it is hard to replace when made in one piece, as is usually done. This requires removal of flywheel and bearing; but it should be done as soon as the

air causes the oil to blow out the bearing. It is possible to replace this without the removal of the flywheel by making the ring in two pieces. By removing the bearing liners, the two ring halves can be brazed together. The important thing to remember is that the air seal must be working, otherwise the oil will be blown off the shaft and the bearings ruined. This is more likely on a ring-oiling bearing than on a force-feed type.

In the engines using an open frame and the rear of the cylinder for the compressor, the troubles of

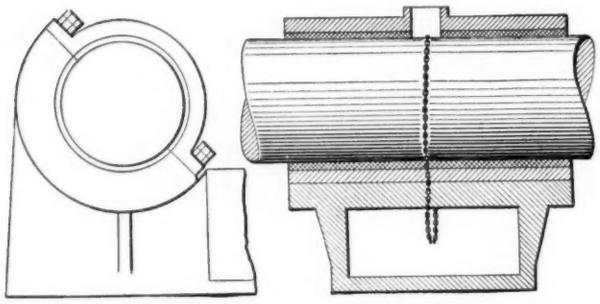


FIG. 1. BEARING ADAPTED FOR ENGINES OF 60 HP. OR LESS

the inclosed frame are largely eliminated. The points requiring attention are the air valve, the piston-rod packing and the crosshead. The last is by far the most important. It is apparent that if the lower crosshead shoe wears, the piston rod will ride on the stuffing-box. The piston is about 40 per cent. as long as the rod. Then, if the crosshead shoe wears one-sixteenth of an inch, the rod will rest on the stuffing-box and the rear end of the piston will be tilted a corresponding amount. Being of considerable length, cylinder cutting will be caused by either the front or rear end of the piston. This has happened in a number of cases where the engineer was careless.

In the low-pressure engine two types of bearings that are commonly employed are shown in Figs. 1 and 2. Fig. 1 is a type best adapted for engines below 50 or 60 hp. per cylinder. It allows the wear to occur at the center of the bottom shell, which is placed at a 45-deg. angle. Consequently, to take up a slight amount of wear, it is necessary only to remove a shim or two from between the two shells. This applies to small engines. Much bearing wear causes the piston to increase the cylinder clearance, lowering the compression. To partly remedy this, thin shims should be inserted under the lower shell, bringing the shaft center back to its original position.

Fig. 2 is a bearing quite generally used on both vertical and horizontal engines. In the horizontal engine the direction of pressure is against one side of the bearing. Both the upper and the lower shells wear oblong, consequently only a small amount of wear can be compensated by means of shims. If the engineer desires to eliminate all play in the bearings, it will be necessary to replace these bearing shells quite often.

For vertical engines this is the most acceptable bearing. The pressure is always downward, and the wear occurs uniformly on the lower shell. It is then an easy matter to shim this shell back to its original position. On a single-cylinder vertical engine, to shim up the shell, it is necessary to jack up the shaft from the outside. On a multicylinder engine, it is best to jack up under the middle crank as well as outside. Before doing this, if the engine is a belted unit, the belt should be removed so that there will be no outside force acting on the engine. The bearing housings are bored in perfect alignment at the time of manufacture; the bearing shells should then be calipered, and sufficient shims should be added to the one which shows the greatest wear to bring its thickness up to the other. Then to bring both up so the shaft is in its original position, equal thickness of shims should be added to each shell.

In order to be able to determine the exact position of the shaft, when the engine is first installed the engineer should place the engine on dead-center and measure the piston position in regard to the end of the cylinder, at the same time measuring the center to center length of the connecting-rod. In the horizontal engine the shaft position may be determined by measuring from the side of the bearing housing when the engine is first erected.

The quarter-box bearing, when used on horizontal engines, is by far the most attractive bearing from the operator's viewpoint. Since the direction of pressure is always toward the front side of the bearing, the rear side need not be provided with a wedge adjustment. It is apparent that it is an easy matter to take up the wear by means of the front wedge. Since the pressure is never against the rear side, this side of the bearing maintains its original position. Of course the weight of the shaft and flywheel is against the bottom part. However, this does not wear as fast as the front side.

One engine builder reverses the position of the wedge, placing it at the rear side. This does not allow adjustment for wear, but merely enables the engineer to

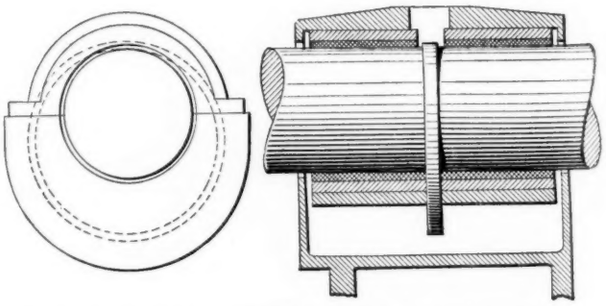


FIG. 2. BEARING COMMONLY USED ON VERTICAL AND HORIZONTAL ENGINES

reduce the shaft play by bringing this side up against the shaft.

In making bearing adjustments the engineer must bear in mind the fact that the shaft must be leveled up true in respect to the housings. To line them up with the cylinder, a good plan is to place the engine on both dead-centers and see that the connecting-rod is in the center of the crank.

The question is frequently asked as to what amount of play should be allowed between the shaft and upper bearing cap. If the bearing be one where the cap does not carry any of the pressure, a good plan is to loosen the cap until the shaft can be "jumped" about one-thousandth of an inch.

In rebabbitting a two-piece bearing shell it is necessary only to clamp the two pieces together with a separator between, insert a mandrel and, after placing the shells in a vertical position, run the babbitt. The shells should be placed on an asbestos sheet and the edges packed with soap or clay. The best plan is to warm the cast-iron shell—this can be done with a blow-torch. The mandrel should be one-half inch smaller in diameter than the shaft. This will allow any dross or surface defects to be removed by boring to correct size. If ring oilers are used, the openings in the top shell for these should be filled with clay before running the babbitt.

If one expects to have a long-lived bearing, it is necessary to scrape it to a perfect fit on the shaft. If no scraper is at hand, an old file ground to shape on the emery wheel will prove serviceable. Even if the old bearing had no oil grooves in the bottom shell, it pays to put them in the new babbitt; this applies even though the ring oilers be used.

With the quarter-box the job of running a new bearing is a little more difficult. The best way is to cast one section at a time, then place them in a clamp and bore them together. To do this it is necessary with some boxes to tap holes in one end and clamp them together by means of a drilled plate, fastened to these drilled holes. In finishing up any of these bearings, it is necessary to cut a bevel at each edge, as in the case of the connecting-rod boxes.

Methods of Lubricating Bearings

Controversy often centers about the best method of lubricating the bearings. In actual practice the most common method is to use ring oilers with an oil cellar cast below the bearing housing. This has the objection of using the same oil over and over again. This oil finally becomes heavily charged with dirt and nonlubricating substances. One engine builder advises replacement of this oil every four months; every two weeks would be better.

An excellent plan, where an oil cellar is used, is to pipe the cellar so that a constant level is maintained, allowing the overflow to go through a filter. After filtering, this oil can be pumped into an overhead tank. From this tank pipes are run to the top of the bearings; in this way one can secure flood or stream lubrication with little extra expense.

For the small plant where first cost is of serious moment, a five-gallon can with a false bottom and the upper part filled with waste, makes a serviceable outfit. A high-grade filter purchased from a filter manufacturer will pay for itself in a short time, in oil saving alone.

Some engines are provided with a mechanical oil pump which feeds the same oil to cylinder and to bearings. This is a poor arrangement as a cheaper oil can be used on the bearings.

The question often arises as to how hot an engine bearing may become before the engineer should consider it dangerous. In all two-stroke-cycle engines the bearings will run warmer than on a four-stroke-cycle engine, since the direction of pressure is not reversed; and, as a result, the lubrication is not so good. In case the bearing becomes too hot to place the hand on, the load should be thrown off the engine immediately. Instead of stopping the engine, the operator should run it slowly until the temperature of the hot bearing is again approximately normal. It is usually noticeable that on a single-flywheel engine the bearing next the flywheel runs warmer than the other bearings. This is due, in a new engine, to the fact that it is often made higher to allow for the increased wear due to the flywheel weight.

Outboard Bearing Sometimes Neglected

On engines employing an outboard bearing to partly support the flywheel and to make the shaft more rigid, the operator is frequently inclined to give this bearing very little attention. Ordinarily, it is not as well built as the main engine bearings, the babbitt metal being cast directly on the bearing housing itself. Probably this outboard bearing shows a greater wear than either of the main bearings and therefore should be given more constant attention. In order to determine whether this bearing is out of line with the main bearings, the belt should be removed, the outboard bearing taken off, and the engine turned over slowly by hand. The engineer can then see whether the bottom half of this bearing is in running contact with the shaft; the best practice is to lower the bottom part of the bearing and then bring it up against the shaft. In this way one can be sure that the bearing is not too high. The cap should then be placed on the bearing and sufficient shims either removed or added to bring this cap in light contact with the shaft. After bolting this cap down securely, the shaft should be "jumped" by means of a pinch bar under the flywheel to see that there is about $\frac{1}{64}$ of an inch play between the bearing cap and the shaft. In case the outboard bearing is not provided with an adjustable wedge to raise or lower it, the best plan is to secure four thin iron wedges and insert one at each corner of the bottom of the bearing. After lining up the bearing, when using these thin wedges, the engineer should fill up the space between the bearing and the foundation with either melted sulphur, lead, or cement grouting. It is necessary to free the surface of the foundation of all oil or other deposits.

Cements for Various Purposes

The following information on cements is quoted from an article in the *General Chemical Bulletin*, by J. B. Barnitt:

One of the principal precautions to be observed in the application of a cement is the condition of the material to be joined. All connections should be properly fitted together with flanges or exposed flat surfaces as nearly coincident as possible. The cement should never be depended upon to do what the pipes or other portions of the apparatus should do. Its function is to cement or seal and nothing more. In most cases one part of the fitting should overlap the other so as to make a small amount of the cement effective. Cement for a joint of this type should be of a nature that may be quickly applied, that is effective while in place and easily removed when desired. An excess of cement should always be avoided to prevent shrinkage, cracks and leaks. The general methods of plastic cement application are varied to suit special cases as follows: (a) Heating the composition to make it plastic until firmly fixed in place; (b) heat applied to the surface to be cemented;

(c) application of the cement with water or a volatile solvent, depending upon the evaporation of the solvent for drying or setting; (d) Moistening the surfaces to be cemented with water, oil, etc. (the vehicle of the cement itself); (e) application of the cement in workable condition, setting taking place by (1) chemical reaction, (2) hydration, (3) oxidation.

Plaster of paris is often used alone as a paste for joints on gas and wood distillation retorts and similar places where rapidity of setting is a requisite. In order to impart strength, a fibrous material such as asbestos is often mixed with it. Shavings, straw, hair and cloth are frequently used as binders when a high temperature is not required, while stone, glass and various mineral substances are used as fillers. The following cements are particularly suitable for oil vapors and hydrocarbon gases: (a) Plaster and water, wet plaster and asbestos, straw, plush trimmings, or hair and wet plaster and broken stone.

Hydraulic cement is used either alone or with sand, asbestos, etc., and is especially resistant to nitric acid. When used with resin or sulphur, it is employed as a filler rather than for any power of setting by hydration.

Clay frequently enters into the composition of plastic cement as a filler. The finely divided condition of the material gives body to a liquid such as linseed oil, which, unless stiffened, would be pervious to a gas, the clay being inert: (a) Clay and linseed oil is suitable for steam, (b) clay, linseed oil, and fireclay for chlorine gas, (c) clay and molasses for oil vapors.

Caustic-lime and linseed-oil mixtures are used as a putty. Chalk or china clay frequently replaces part of the lime, but enough should remain to maintain the caustic property necessary to the formation of a certain amount of lime soap.

Asphalt and pitch are used interchangeably in plastic cements, pitch making the stronger binder. Tar is of less value on account of the light oils and water contained in it. For waterproofing, melted asphalt with a small amount of paraffin added, and in particular cases boiled oil, is used. Pitch, eight parts; resin, six parts; wax, one part; plaster, one-fourth to one-half part; or pitch, eight parts; resin, seven parts; sulphur, two parts; stone-powder, one part are used to unite slate slabs and stoneware for engineering and chemical purposes. If acid vapors or corrosive gases come in contact with the cement, limestone should not be the powder used, otherwise it is best. Wax prevents the composition from becoming brittle. Plastic cements for calking must be both tough and elastic, and have the added property of expanding and contracting with the joint to which they are applied.

Resin, shellac and wax make a strong stone cement having little body and applied in layers. (a) Resin, eight parts; wax, one part; turpentine, one part. For nitric and hydrochloric acid vapors. (b) Resin, one part; sulphur, one part; fireclay, two parts. Sulphur gives great hardness and permanency in resin cements. Good waterproofing cements are: (c) Resin, one part; wax, one part; powdered stone, two parts. (d) Shellac, five parts; wax, one part; turpentine, one part; chalk, eight to ten parts. For a soft air-tight paste for ground-glass surfaces: (e) Wax, one part; vaseline, one part. A strong cement without body for metals (not copper), porcelain, and glass: (f) Powdered shellac, one part; ammonia water, ten parts. Allow to stand until solution is effected.

Rubber, because of its toughness, elasticity and other qualities, is a very useful cement. As a leather cement: (a) Asphalt, one part; resin, one part; gutta percha, four parts; carbon disulphide, 20 parts. As a resistant to acid vapors: (b) Rubber, one part; linseed oil, two parts; fireclay, three parts. A plain rubber cement: (c) Cut crude rubber in small pieces and then add carbon disulphide or benzol, allowing the rubber to dissolve. Corks and wood are made impervious to water by soaking them in this solution.

Linseed oil is one of the most generally used materials for cementing purposes. For aqueous vapors: (a) China clay and linseed oil. (b) Lime and linseed oil, forming the well-known putty. (c) Red or white lead and linseed oil. The foregoing mixtures become very strong when set, and are best diluted with powdered glass, clay or graphite. (d) Oxide of iron and linseed oil.

Cements of casein, albumen and glue, if properly made, become very tough and tenacious, are resistant to moderate heat and oil vapors but not to acid fumes: (a) Finely powdered casein, 12 parts; fresh slaked lime, 50 parts; fine sand, 50 parts, and enough water to make a thick mass. A strong cement for ground joints, standing a moderate heat: (b) Casein in fine powder, one part; rubbed with silicate of soda, three parts. (c) White of egg made into a paste with slaked lime. This should be used immediately after being made. A composition for soaking corks, wood packing, etc., to render impervious to oil vapors: (d) Gelatin, two parts; glycerin, one part; water, six parts.

Silicate and oxychloride cements for oil vapors standing highest heat: (a) Paste of sodium silicate and asbestos. For gaskets for superheated steam retorts, furnaces, etc.: (b) Sodium silicate and glass. (c) Sodium silicate, 50 parts; asbestos, 15 parts; slaked lime, ten parts. A metal cement: (d) Sodium silicate, one part; oxide of zinc, lead or iron, singly or mixed, one part. (e) Zinc oxide, two parts; zinc chloride, one part; water to make a paste. (f) Magnesium oxide, two parts; magnesium chloride, one part; water to make a paste.

Flour and starch: (a) Flaxseed makes a very tough cement, but does not withstand water. (b) Flour and molasses to a stiff paste; a permanent cement for ordinary temperatures impervious but attacked by condensing steam and nitric vapors. (c) Stiff flour paste and concentrated zinc-chloride solution.

Miscellaneous, for insertion of glass tubes in brass or iron: (a) Litharge and glycerin mixed to a stiff paste. For high heat: (b) Alumina, one part; sand, four parts; slaked lime, one part; borax, one-half part; water.—*The Popular Engineer.*

Finding the Contents of a Horizontal Cylindrical Tank

By Franz Szabo

The accompanying alignment chart has been constructed with the aim of finding without much trouble the contents of tanks of any size within the limits of the chart and at any level of the liquid. Of course it does not take into consideration the curvature of the heads, differences in the diameter of the tank due to lap

joints, or any irregularity in the outside shape of the tank. The values given are reasonably accurate for practical purposes.

Referring to the chart, the scale *A* shows the diameter of tank in feet and inches and has a range of from 2 to 20 ft. Scale *B* shows the length of tank in feet and inches, ranging from 4 to 40 ft. Scale *C* serves two purposes—it indicates the maximum capacity of the tank in cubic feet on the left and in U. S. gallons on the right of the scale, and it also serves as a dummy scale for finding the contents at various levels of the liquid on scale *E*. Locating the diameter of the tank on scale *A*, the length on scale *B*, and joining these two points by a straight line, the point of intersection of this straight line and scale *C* will indicate the maximum capacity of the tank in cubic feet and U. S. gallons.

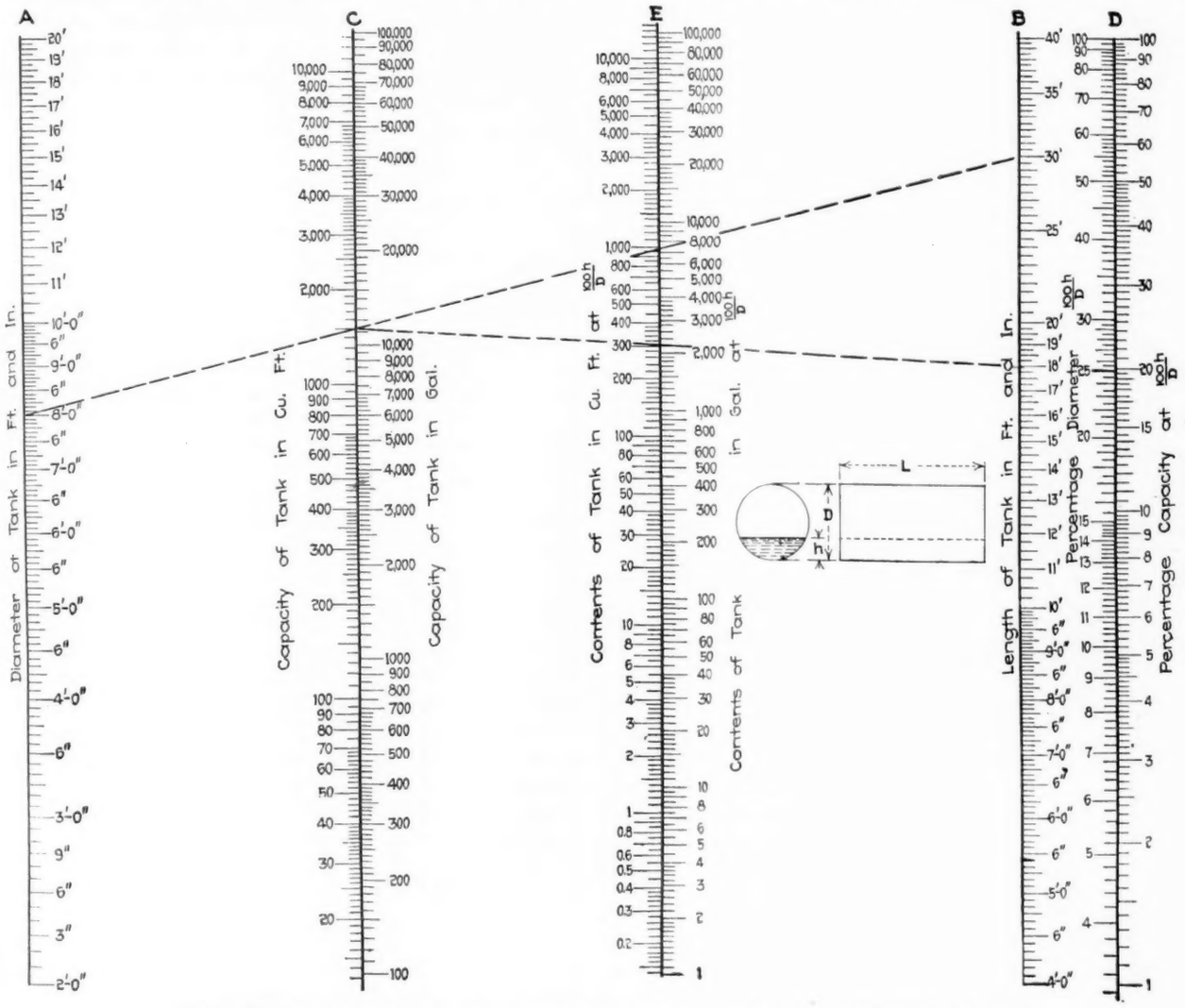
Expressing the height of the liquid in the tank in percentage of diameter, or $\frac{100h}{D}$, locating this value on the left side of scale *D* and joining this point by a straight line with the point of intersection on scale *C*, the contents of the tank is found at the point of intersection of the straight line and scale *E*, either in cubic feet on the left side of the scale or in U. S. gallons on the right side of the scale. An example will illustrate the procedure: Assume a tank 8 ft. in diameter and 30 ft. long, with the liquid at a depth of 2 ft. from the bottom, and let it be required to find the contents as well as the maximum capacity, in both gallons and cubic feet.

Locate 8 ft. on scale *A* and 30 ft. on scale *B* and draw a straight line through these two points as shown on the chart. The point of intersection of this straight line and scale *C* indicates the maximum amount of liquid the tank will hold, 11,300 gal. or 1510 cu.ft. in this case.

The height *h* of the liquid, expressed as a percentage of the diameter of the tank, is $\frac{100h}{D} = \frac{100 \times 2}{8} = 25$ per cent.. Drawing a straight line from the point of intersection on scale *C* to 25 on the left side of scale *D*, the point of intersection of the straight line and scale *E* indicates the amount of liquid in the tank, about 2200 gal. or 300 cu.ft., in this case.

The right side of scale *D* indicates the corresponding percentage capacity of the tank for any height of liquid expressed as a percentage of the diameter.

Scales *A*, *B* and *C* may also be used for finding the contents of vertical tanks by substituting the height of liquid in the tank for the length of the tank.



ALIGNMENT CHART FOR FINDING CONTENTS OF HORIZONTAL CYLINDRICAL TANK

Visits of Inspector Brown—XXXIV

By J. E. TERMAN

The Chief explains the importance of safety-valve, vent and blowoff connections in an economizer. Gas passages and dampers and how the dampers should be manipulated. Closing off an economizer that has been in service. Cutting in an economizer that has been idle. Economizer should be kept clean. Inspection. Inspector's duty to the engineer.

"WELL, here I am again, Chief, ready for another injection of that economizer dope," said Brown, as he stuck his head in the door leading to the Chief's office.

"Come in. I have just finished my day's work and we can have a half-hour or more to chat," said the Chief. "Let's see, we had got through the danger of parallel operation either by the way of the feed main or the bypass connection in our last talk. Well, there are other connections to an economizer that are important, and you don't want to overlook any of them when you are making an inspection of one of these vessels. While we must stick to the fact that the temperature control of the water in an economizer is the most important single feature connected with its operation, still the pressure-limiting device, the safety valve, is a very essential attachment. The safety valves for an economizer are, of course, in reality water-relief valves. I don't believe that, up to the present time, there is an entirely satisfactory valve made for this kind of service.

Valves Should Receive Proper Attention

"The minute a water-relief valve begins to function, it usually commences to go bad. Probably one of the reasons is that the water carries grit and other substances in suspension and some of this always manages to stop between the disk and the seat of the valve or mars the seat in passing over it. In any event such valves cut and leak badly unless they are given extraordinary attention. They should be ground in the very first time they show a tendency to leak. I believe that the proper attention to such valves, Brown, will more aptly illustrate the old adage of a stitch in time saves nine than any other piece of apparatus around a power house. It is necessary that the outlet connections from the safety valves be placed so that any tendency to leak will be observed at once. If a few of the first drops of hot water from them, as they began to leak, could be directed so as to fall on top of the chief engineer's bald head, the arrangment would be ideal. Seriously though, Brown, while the discharge ends of the safety-valve outlet connections should be readily visible, they should be arranged so that there will be no danger of scalding anyone when the valves operate. The outlet pipes should fall away from the valves, so that all the water that is discharged will drain toward the outlet end of the discharge pipe. The safety valves should be located on the top manifold connections."

"How many safety valves should be used on an economizer, Chief?" asked Brown.

"That is a hard question to answer directly, but there should be at least one safety valve on each economizer. The capacity of the valve, or valves if more than one, together with the capacity of the relief valves on the line from the pump should be sufficient to care for all the water that might be discharged by the feed pump. This matter of having relief-valve capacity capable of caring for all the water that can be pumped is of particular importance where the pump-cylinder ratios are such that the pressure from the pump might be considerably above the safe pressure for the economizer."

"I should think, Chief, that a calculation could be made of the maximum heat that might be delivered to the economizer by the gases, and the safety-valve capacity required could be based on this calculation in the same way as for boilers," said Brown.

"That could be done, Brown, and it would be interesting, but of no practical value as far as the assumption that the valve would relieve any steam formed. When steam is generated in an economizer, the only safety to be found in connection with a safety valve is in the name. As I have told you before, the only real way to prevent economizer explosions is to keep the temperature down below the steaming point, whatever that may be under the pressure that is being carried.

Vent Connections Are Important

"Vent connections are also important parts of the equipment of an economizer, Brown. Unless the air in an economizer is vented out when it is being filled with water, there might be a considerable pocket of air formed in the top headers. If hot gases should be passed through an economizer before this air was discharged, the top headers might become so hot that there would be danger of their coming off the tubes. In one type of economizer, inverted U's form the connection between the top manifold connection and the sections; on top of each of these U's is a pet-cock. These cocks should be open when filling the economizer with water. Vent connections should always be open when an economizer is out of service. The blowoff connections are also an important part of the economizer equipment and should be properly arranged. The pipe from the blowoff valves to the discharge end should slope away from the valves and not be pocketed at any point. This is of special importance if any portion of the pipe extends outside the boiler room where it might be exposed to freezing temperatures.

How to Manipulate the Dampers

"I believe this about concludes the connections to the pressure parts of an economizer," said the Chief. "But there are still other very important parts of the equipment of such vessels to be considered. For example, the gas passages and dampers and how the dampers should be manipulated, are all important questions. If an economizer is to be cut out of service without the boilers which serve it being stopped, it is necessary that a bypass connection for the flue gases be provided. This must, of course, be provided with a good-fitting

damper. Gases that leak by the bypass damper when the economizer is in operation represent a direct loss in efficiency. There must be an inlet and an outlet damper for the economizer; and the inlet damper admitting the gases to the economizer should be tight-fitting. None of the three dampers mentioned can be used for combustion control, so that a fourth one, known as the main damper, should be provided, and to this damper should be attached the automatic damper regulator. Most economizer explosions, by some, are attributed to the explosion of gases in the economizer, and you will notice that our policy covers the assured against such accidents. Possibly a gas explosion has been the cause of a serious economizer explosion, but I have never seen one, Brown. However, gas explosions do occur in economizers, and they are likely to cause injury to the operatives if nothing more serious; they should be guarded against as far as possible. Mismanipulation of the dampers or poor-fitting dampers are liable to lead to such accidents. While the inlet damper should be particularly well fitted, the outlet damper need not be so tight. In closing off an economizer that has been in service, the following procedure should be adopted:

"First, open the bypass damper wide, then close the inlet damper tight. Next, if it is desired to get the pressure off the economizer, open the water bypass valves so that water may flow to the boilers through this connection. The next thing to do is to open the soot doors leading to the chamber beneath the economizer, also any ventilation doors that have been provided in the setting or casing walls. This last operation is for the purpose of airing out the economizer setting, so that it may be entered safely. After a reasonable time has elapsed, say fifteen or twenty minutes, the outlet damper may be closed. An economizer should be allowed a reasonable time to cool before draining off the water, which may be done after closing the inlet valve and opening one of the vent connections. It is safest to have the outlet damper cracked open slightly and a soot-pit or ventilation door at the opposite end of the economizer open, during the time that an economizer is idle. This will prevent the possibility of an explosive mixture of gas being formed in the setting, as might occur due to leakage at the dampers. You should always be careful, Brown, to see that this airing-out process is properly attended to before you start an inspection."

How to Cut In Economizer

"How about cutting in an economizer that has been idle, Chief?" asked Brown.

"Well, the real way to accomplish this is to place it in service when the boilers that serve it with gas are placed in service. If this is done, it is merely necessary to open all the valves that should be open when the economizer is in use and close those which should be closed, starting up the boilers in the regular way without considering the economizer. If this method is not feasible, the procedure should be about as follows: Open the valves leading to and from the economizer and close the water bypass valves if open, so that water must flow through the economizer to the boilers. Before doing anything else, be sure that the economizer has been properly aired by opening the vent connections; it should be free from air before the hot gases are allowed to pass through it. Next, open the outlet damper, and after that has been fully opened, open the inlet damper. After a reasonable time for the parts to warm up, the bypass damper should be closed, so that all the gases will pass through the economizer on their way to the stack. One of the things, Brown, that is most important to the economizer owner who is expecting a return on the money he has invested, is keeping the external surfaces of the economizer clean. You should always try to impress the importance of this on the engineer. An economizer without a scraper equipment to keep the soot removed from the tubes would be about as much use as an airplane without an engine. The scraper gear should be kept in good condition, and the scrapers should travel the full length of the tubes. At best, the inspection of an economizer is most difficult, and you can't hope to learn much about the condition of the vessel from an inspection of the external surfaces unless they have been kept reasonably clean.

Watching for Leaks

"You should watch particularly for evidence of leaking, where the tubes and headers are joined. Often a leak which apparently comes from the tube ends will be found to come from a crack in the header on closer examination. Such cracks often form in the ligament between the tube holes. In inspecting the internal surfaces, enough caps should be removed from the top headers to give a general idea of the internal condition of the tubes. Internal corrosion will be found most pronounced near the entrance end of the economizer, and for that reason the greatest number of caps should be removed in the vicinity of this end. You will often find the internal surfaces of the tubes covered with a substance like graphite; that is, the iron of the tube has apparently undergone a change, the result being a change to this graphite-like substance. You will often be deceived into thinking that this surface is in reality the tube, for it has about the same appearance. The difference may be detected by scraping the surface with a sharp point. It is best not to remove this surface, for the result is the exposure of the surface of the iron beneath to further action. The action is more rapid on the fresh surface exposed in this way than on that covered by the graphite-like formation, therefore economizer tubes should not be cleaned internally with any form of tube cleaner that might seriously disturb this formation. A hand-operated scraper is usually a good tool for cleaning the internal surfaces of the tubes. The only reason for removing this deposit is for the purpose of obtaining a correct idea of the depth to which it extends. This may be accomplished by cutting through it with a sharp-pointed tool at a few selected points.

Duty of Inspectors to Prevent Accidents

"To prevent economizer accidents, Brown, is the chief duty of the inspectors who have to examine such vessels, and that may best be done by observing the following rules in making such inspections: First, try to impress the engineer in charge of the plant with the dangerous conditions that may arise in the operation of such vessels. Tell him of some of the disastrous explosions that have occurred with economizers. Try to impress him thoroughly with the fact that the most

important feature as regards safety in the operation of economizers is to keep the temperature within safe bounds. Show him that the mere limiting of the pressure to an amount that should be considered safe, cannot possibly insure that the economizer will not explode. Show him how an unsafe temperature may be most easily reached unless a sufficient supply of water is passing through the economizer at all times when the heated gases are flowing around the tubes. Explain to him how easy it is to have a portion of the water that should be keeping the temperature of the economizer normal, flowing around it through a bypass connection or through any valves that may cut two or more economizers in parallel, if there is more than one economizer in the plant. Impress him with the importance of having one man, preferably the chief himself, attend to the handling of any valves connected with the economizer or the main feed line. Tell him to be sure that whoever manipulates these valves thoroughly understands the danger that may exist unless they are properly handled. Have the chief tag the valves, so that it will not be necessary to rely on memory to operate them properly. Try your best to prevent the installation of valves in the feed main that will permit the economizers to be placed in parallel, where there is more than one economizer in the plant. Explain fully the steps necessary and the sequence in which they should be performed to safely cut an economizer in and to take one off when already in service. After attending to all these matters, Brown, if you make a reasonable inspection of the economizer to determine its condition, you can feel that you have done your full duty to the company and to its patron."

"Say, Chief; when we started on this subject, you told me that you thought the present design of economizers would be superseded, at least where high pressures were to be used. What kind of economizer design do you think will be used for high-pressure service in the future?"

Present Type for Moderate Pressures Only

"I may have given you a false impression, Brown, when I made that statement, and I am glad that you have brought it up, so that I may explain fully what I meant. The present type of economizers may be a part of power-plant equipment for many days to come, but I believe such vessels will be used only for moderate pressures, say only a few pounds at most. My idea of the proper kind of economizer equipment for a high-pressure plant would be a comparatively small amount of economizer surface placed next to the boilers, preferably in the boiler setting, to receive the gases as they leave the boiler surface. This economizer would, of course, pass the water directly to the boiler and would be built in a manner similar to a boiler; that is, no cast-iron parts, tubes expanded in, and capable of generating steam if necessary without danger of explosion. Outside the boiler setting there would be provided another economizer to take the gases as they left the first one, and this would be served with water from the hotwell or whatever source of supply was available. This latter economizer could be of the same design, and no doubt preferably so, as now used. There would be no particular pressure on it, because a pump capable of boosting up a pressure required to feed the boilers would be placed between this economizer and the one located in the boiler setting. The cast-iron economizer could be served by gravity from a feed tank, and owing to the fact that it would operate at atmospheric pressure if it should get sufficiently hot to cause steaming, no particular harm would result. The pump used for boosting the pressure up to that required to feed the boilers could be located lower than the cast-iron economizer, and the inlet connection to this pump taken from the lower header of an outlet connection. This arrangement would prevent steam from interfering with the action of this pump. The initial heating of the feed water in this cast-iron economizer would, in a large measure if not entirely, remove any tendency toward internal corrosion in the second steel economizer. External corrosion of a serious character would be eliminated in the case of the high-pressure economizer, because it would be supplied with water too hot to permit sweating."

"Well, Chief, I am certainly obliged to you for the instructions you have given me on this subject. I will devote the most of my time, when engaged in inspecting economizers in the future, to seeing that the connections to them are properly arranged. I will also make it a point to see that the operatives thoroughly understand the dangers due to the mismanipulation of valves. I can see that it is this part of the inspection work that counts for most in preventing economizer accidents."

"Yes, Brown, it is a fact that in the inspection of economizers the examination of the economizer itself is a matter of rather secondary importance, as far as preventing serious accidents is concerned."

Temperature Was Too High

By E. C. Parham

What carbonizes the insulation of electric machines that include carbonizable material is the final temperature of operation. This temperature may be due to low initial temperature and excessive temperature rise incident to overloads or it may be due to excessive initial temperature to which is added moderate temperature rise of operation. In either case it is the sum of the two that counts. A machine that will safely carry a certain overload under average climatic conditions and with good ventilating conditions, cannot be expected to give the same degree of satisfaction when installed in the boiler room of a steamship that plies in the tropics, unless it has been furnished with an understanding of operating conditions.

All temperatures having to do with guarantees of electric machines are expressed in Centigrade degrees. A vessel that had been plying in the Northern coast trade was sold into the Southern service. The equipment of the vessel included a small generator which was used for lighting and which was installed in the boiler room. The machine had never given any trouble up to the time of changing hands, but it burned out soon afterward and the new owners held out for the cost of repairs, claiming that the temperature just before the failure was over 200 deg. The temperature probably was over 200 deg., but it developed that it had been taken with a Fahrenheit thermometer and later, when the vessel reached port, an investigation disclosed that failure had been due to a bearing running hot and letting the armature down on the polepieces.

Reconnecting Induction Motors for Change in Number of Poles—II

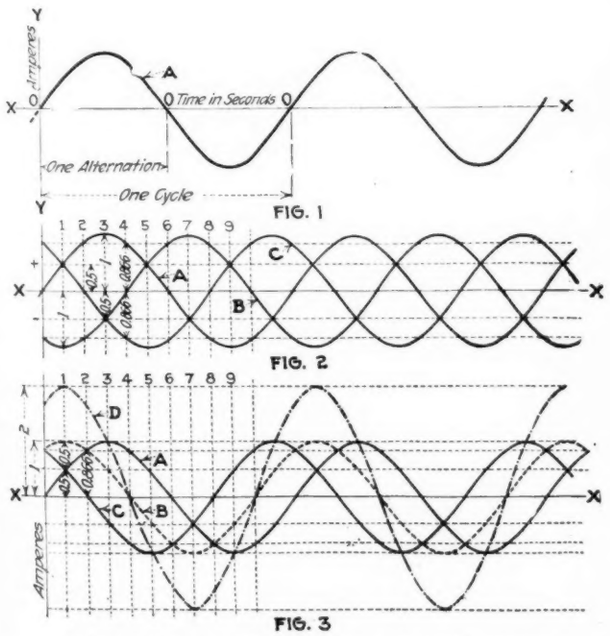
By A. M. DUDLEY

Designing Engineer, Westinghouse Electric and Manufacturing Co.

Explanation of how the magnetic field is built up. Why one phase of a three-phase winding is reversed and how interchanging two leads changes the direction of rotation.

THE statement was made in the last article, Apr. 9 issue, that a graphical picture would be given of the effect on the magnetic field of chording the individual coils in a winding to a greater or less pitch, or throw, and also that the effect would be shown of connecting a given winding for different numbers of poles and thereby causing the motor to run at different speeds. The method that will be used to consider these two cases is a very easy one and, while elementary, is described in detail as it offers the best possible method of studying induction-motor windings from the viewpoint of either the designing engineer or the operating electrician.

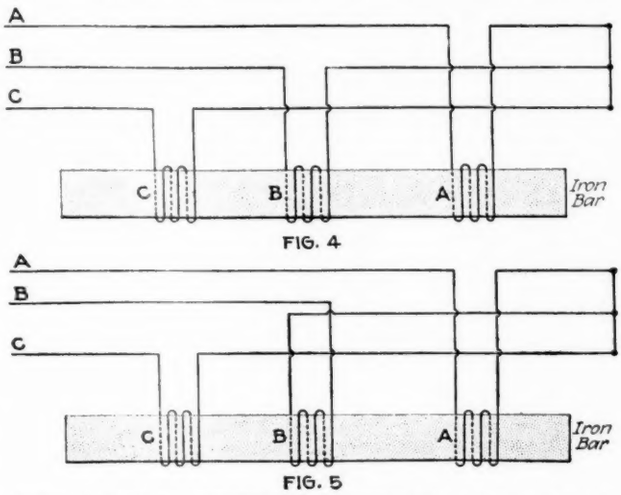
By means of this method the rotating magnetic field can be explained and studied and the readiest possible answer given to such questions as, Why does reversing two leads of a three-phase motor reverse its direction of rotation? Why is a phase-wound rotor always three-phase, whether the stator is for two-phase or three-phase? Also such questions as the effect of chording the coil and changing the number of poles are readily analyzed.



FIGS. 1 TO 3. ALTERNATING CURRENT CURVES

Fig. 1—Single-phase curve. Fig. 2—Curves for a three-phase circuit. Fig. 3—Same as Fig. 2, with curve B reversed

The confidence that will be gained in the understanding of induction-motor operation and troubles will well repay the amount of study required to master it, and the amount of electrical knowledge required is not so great as to discourage anyone who has even a speaking acquaintance with alternating current and its behavior. No claim is made that this is a new method. This is how it applies, for example, to a three-phase problem:



FIGS. 4 AND 5. THREE-PHASE WINDING ON IRON BAR

Fig. 4—Three-phase winding, all coils connected in the same relation. Fig. 5—Same as Fig. 4, except coil B is reversed.

In each of the three wires of a three-phase circuit which is carrying load is an alternating current which several times a second increases from zero to a maximum value in one direction, decreases to zero and increases in the opposite direction to a maximum value and again decreases to zero, thus completing one "round trip," which is called a "cycle." If a pencil could be attached to this current and a piece of paper be drawn under it as the current rose and fell, after the manner that indicator cards are made on a steam engine, its "card," or curve, would have the characteristic shape shown in Fig. 1. Here it will be noticed that the time in fractions of seconds is along the horizontal line *XX* and the value of the current in amperes is along the vertical line *YY*.

All three currents of a three-phase circuit will trace a similar card to that in Fig. 1, but they do not all reach a maximum at the same instant nor pass through zero at the same instant, but are evenly spaced the same distance apart at all times so that if the indicator be connected to all three lines at once, the combined card would be that shown in Fig. 2 where *A* is the card for phase 1, *B* for phase 2 and *C* for phase 3. The values above the *XX* line are considered plus and the values below the line negative. It is the evenly spaced coils in the alternating-current generator winding that keep the current in all three phases of equal value and with a constant spacing with regard to each other.

Assume that each one of the three-phase lines is wound an equal number of times around the same iron bar, as in Fig. 4. Whenever a coil is placed around iron

and current flows in the coil, it sets up magnetic lines, or flux, and the iron becomes a magnet. It is evident, then, from Fig. 4, that any one of the three coils by itself would make a magnet of the iron bar which would have its north pole at one end at one instant and a south pole at the same end the next instant as the current changed its direction according to the curve in Fig. 1.

However, when all three coils work together on the

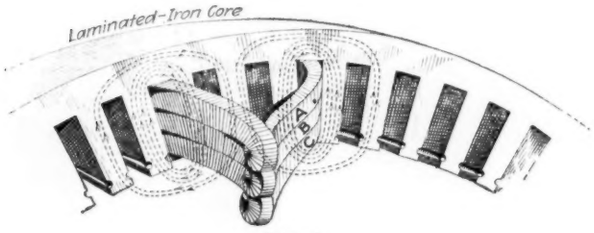


FIG. 6

SECTION OF A STATOR CORE, SHOWING THREE COILS LOCATED IN ONE SLOT

bar (Fig. 4) there is no magnetism set up, because at any instant the current in one coil is equal in amount and opposite in direction to the currents in the other two coils. This can be seen from Fig. 2. Take, for instance, the time marked by the vertical line 1. At this instant the A and C phases are measured above the horizontal line XX and hence are positive or plus in value and are each equal to $+0.5$, while the B phase is measured below the X line and hence negative or minus value to -1. Therefore, the sum of all three currents is zero because $+(0.5 \times 2) - 1 = 0$.

At the instant 2, $C = O$, $A = +0.866$ and $B = -0.866$ and the sum of the three currents is zero. At instant 3, $A = +1$, $B = -0.5$, and $C = -0.5$, total $= 0$; at the instant 4, $A = +0.866$, $B = O$ and $C = -0.866$, total $= 0$; and so on at all points the sum of the three currents is zero. Therefore in Fig. 4 there will be no magnetism in the iron bar, since at all times there is an equal number of ampere turns in the coils trying to force the magnetism in each direction.

The next step is to reverse one coil, as shown at B in Fig. 5, and the bar immediately becomes a strong magnet, reversing its poles from instant to instant according to the change in direction of the curve D in Fig. 3. Reversing one coil in Fig. 5 is the equivalent of reversing the current in one phase of the generator. This is indicated in Fig. 3, in which curve B is shown plotted above the line where it is below the line in Fig. 2, and vice versa. The sum of the three curves A, B and C, Fig. 3, gives a resultant curve D, which represents the current that will be effective in magnetizing the core, Fig. 5. It will be seen that the A and C curves in Fig. 3 are the same as in Fig. 2, but the B curve is turned over, or reversed, since the B coil is reversed in Fig. 5. Curve D is obtained by adding the values of the three currents at any point. For example, at the time marked by the vertical line 1, $A = +0.5$, $C = +0.5$ and $B = +1$, hence $D = +2$. At the time marked by the vertical line 3, $A = +1$, $B = +0.5$ and $C = -0.5$, hence $D = +1$. Also at time 4, $A = +0.866$, $B = O$ and $C = -0.866$, hence $D = O$. In this manner the curve D is obtained, and it serves as an indicator card of the magnetism in the iron bar in Fig. 5.

This conception of three-phase coils making a magnet whose flux or field varies in value and direction according to the curve D in Fig. 3 can be readily transferred to the stator of an induction motor, as shown in Fig. 6. Here is shown a part of a laminated core slotted on the inner periphery, and in two of these slots are shown three coils, A, B and C, to correspond to the coils in Fig. 5. Assume the three coils to be connected in star and to a three-phase circuit. A magnetic field will then flow into the air gap and back through the core, as shown by the curved dotted lines and arrowheads. This magnetic field will flow in the direction of the arrows for a fraction of a second, then fall to zero, and increase to a maximum in the direction opposite to the arrowheads, and so on. In other words, the three coils working together would make first a north pole and then a south pole on the inner periphery, and repeat, and the amount and direction of the magnetism in the iron between the two sides of the coil could be measured by taking the distance from points on the curve D, Fig. 3, from the horizontal reference line and calling all points above that line north values and below the line south values.

For example, at the position marked 1 the magnetic value would be a maximum north value, at 3 it would be 0.5 north, at 4 zero, at 5 it would be 0.5 south, and at 7 a maximum south value, and so on. There would be no tendency, however, for this magnetic field to rotate or travel around the stator as it does in an induction motor. It would simply stand still in space and alternate backward and forward through the coil as described. In order to get the rotating motion, it will be necessary to separate the three coils and put each one in a separate slot, as shown in Fig. 7, as they would be in any normal induction motor.

A section cut through the core and coils, Fig. 7, is shown in Fig. 8 with one side of each coil in the bottom of slots 1, 2 and 3 and marked A, B, C, respectively, and

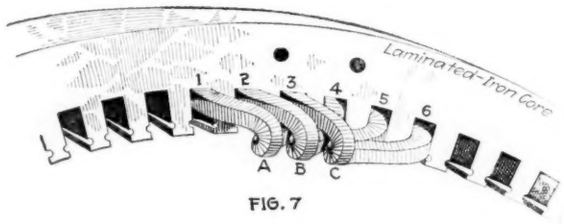


FIG. 7

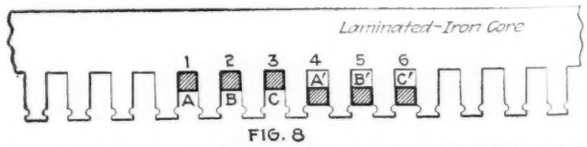


FIG. 8

FIGS. 7 AND 8. SAME AS FIG. 6, EXCEPT COILS ARE DISTRIBUTED IN THE SLOTS

their other sides in the top of slots 4, 5 and 6 and marked A', B', C', respectively. By means of Figs. 3 and 8 taken together, it is possible to build up small pictures of the magnetic field from instant to instant and show how it moves or rotates around in the stator core and air gap. These small pictures, of which one series is shown in Fig. 9 and another in Fig. 10, can be very well compared to the individual small pictures on a moving-picture film as they appear when the film is at rest, and the rotating magnetic field as it really exists could be compared to the same film when in motion and

thrown on the screen. The method of making these small pictures is very simple and is as follows:

At the top of Fig. 9 is a section through the coils and core, Fig. 7, the same as that given in Fig. 8. A current is assumed to be flowing in each coil, and the value of that current is taken from the curve marked with the same letter in Fig. 3. For example, at the time represented by the vertical line 1 in Fig. 3, curve *B* is at its maximum value, which is called +1, because it is above the horizontal reference line, and curves *A* and *C* are each at a value of +0.5, since they are half their maximum value and are also above the reference line *XX*. Similarly, at the time represented by the vertical line 2, which is called position 2, in Fig. 9, the value of the *A* and *B* curves is +0.866 and the *C* curve is zero. The value 0.866 is obtained because these current curves are all what are known as sine curves and the reference points or positions 1, 2, 3, etc., are taken $\frac{1}{12}$ of a complete cycle apart.

A complete cycle is known as 360 electrical degrees similar to the 360 mechanical degrees in a circle, and hence the reference positions 1, 2, 3, etc., are $\frac{1}{12}$ of 360 deg. or 30 deg. apart. From a table of natural sines such as is found in any handbook, it will be found that the sine of 30 deg. = 0.5, sine of 60 deg. = 0.866, sine of 90 deg. = 1, sine of 120 deg. = 0.866, sine of 150 deg. = 0.5 and sine of 180 deg. = 0. Continuing from 180 deg. to 360 deg., the same values recur with a minus sign since they are measured below the horizontal reference line. So that it is these values which are used in plotting the pictures in Fig. 9, and the values for different positions are given in the left-hand column in the figure.

From Fig. 8 we have the position of the coils, and from Fig. 3 we have the value of the current in each coil as given in the column on the left of Fig. 9. Then if the values of these currents are plotted or drawn, the resulting curve is a measure of the magnetic field, since

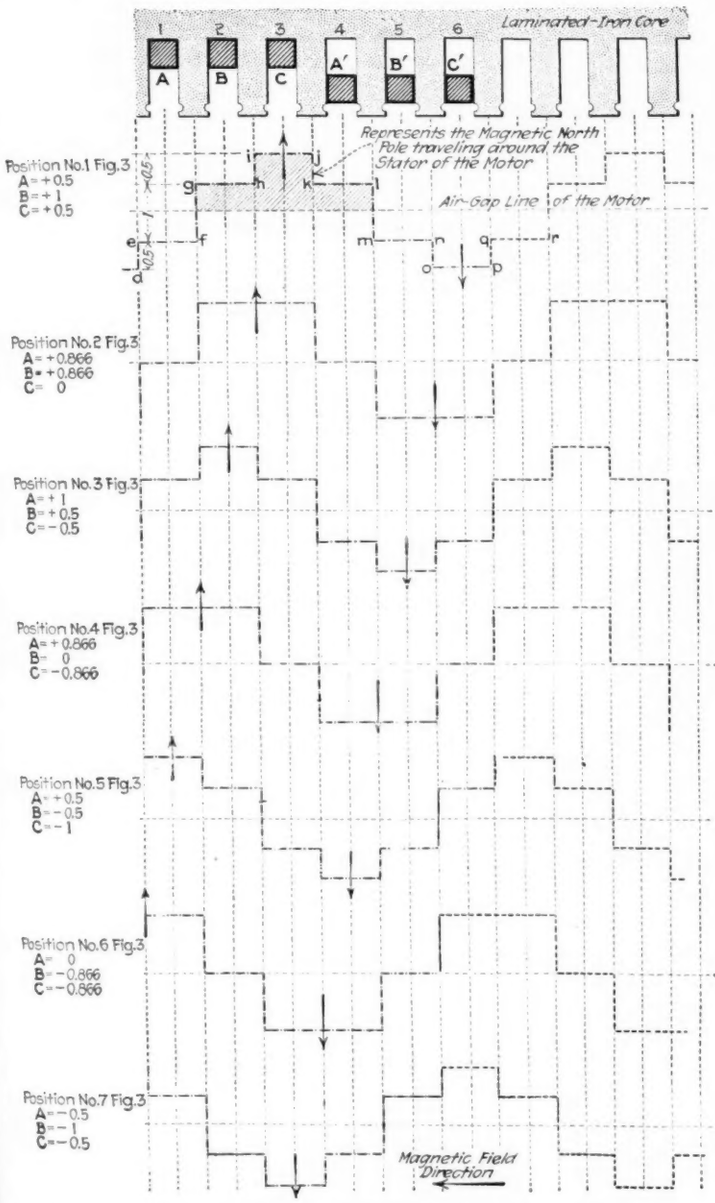

Laminated-Iron Core
Represents the Magnetic North Pole traveling around the Stator of the Motor
Air-Gap Line of the Motor
Position No.1 Fig.3 A=+0.5 B=+1 C=+0.5
Position No.2 Fig.3 A=+0.866 B=+0.866 C=0
Position No.3 Fig.3 A=+1 B=+0.5 C=-0.5
Position No.4 Fig.3 A=+0.866 B=0 C=-0.866
Position No.5 Fig.3 A=+0.5 B=-0.5 C=-1
Position No.6 Fig.3 A=0 B=-0.866 C=-0.866
Position No.7 Fig.3 A=-0.5 B=-1 C=-0.5
Magnetic Field Direction

FIG. 9. HOW THE ROTATING MAGNETIC FIELD IS BUILT UP IN AN INDUCTION MOTOR

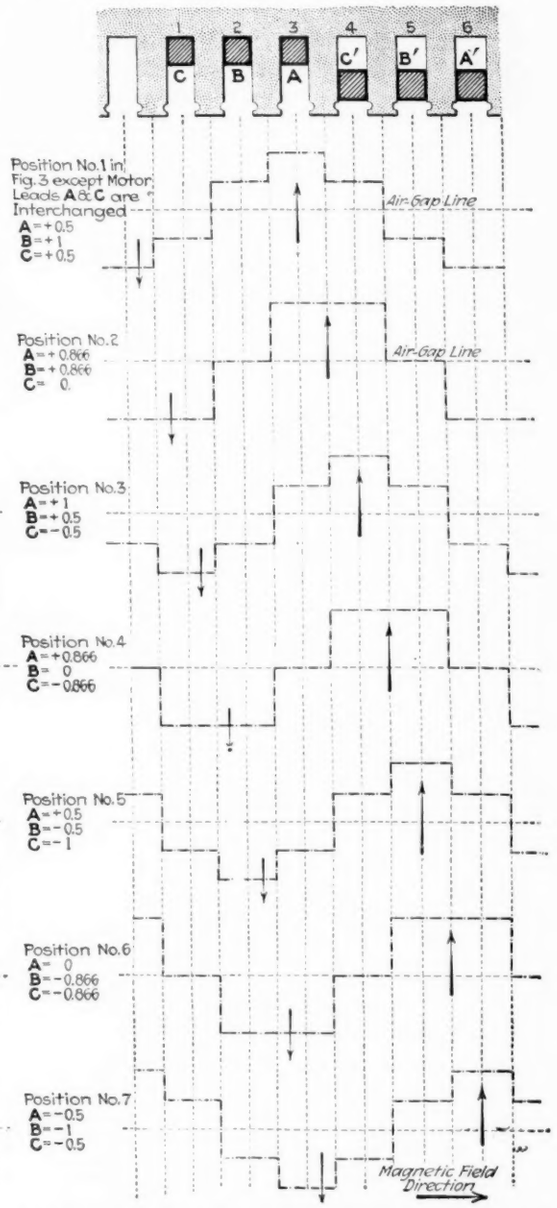

Position No.1 in Fig.3 except Motor Leads A & C are Interchanged A=+0.5 B=+1 C=+0.5
Air-Gap Line
Position No.2 A=+0.866 B=+0.866 C=0
Position No.3 A=+1 B=+0.5 C=-0.5
Position No.4 A=+0.866 B=0 C=-0.866
Position No.5 A=+0.5 B=-0.5 C=-1
Position No.6 A=0 B=-0.866 C=-0.866
Position No.7 A=-0.5 B=-1 C=-0.5
Magnetic Field Direction

FIG. 10. SAME AS FIG. 9 EXCEPT MOTOR LEADS A AND C ARE INTERCHANGED

such a field depends on the number of turns of wire and the current flowing in the coil. It remains, then, only to draw the small figures or curves in Fig. 9 in the following manner:

Starting from any arbitrary point at as *d*, Fig. 9, the line moves in direction and amount according to the value of the current in slot 1. Slot 1 contains the *A* coil and the value of the current is +0.5 as is shown on the left; since the direction of plus is up, the line is drawn upward from *d* to *e* and *ef* is drawn horizontally, representing by its height above *d* the current in No. 1 slot and the magnetic field at that point. From *f* the line goes up to *g*, making *fg* twice as long as *de* because the *B* coil is in No. 2 slot and the value of the current in the *B* coil is +1, or twice that in *A*, and the line *gh* is drawn horizontally, representing by its height above *d* the current in slot 1 + slot 2 and therefore the magnetic field at that point. From *h* the line goes up to *i* because the *C* coil is in slot 3 and the current in the *C* coil as shown at the left at that instant is +0.5. The line *ij* is drawn horizontally, representing by its height above *d* the combined currents in slots 1 plus 2 plus 3 and therefore the magnetic field at that point. From *j* the line drops down to *k* because the *A'* conductor is in slot 4 and the *A'* conductor is the other side of the *A* coil and hence the current in it is in the opposite direction to that in the *A* side. By referring to the column at the left of the figure, if the current in the *A* side was considered +0.5, the current in the *A'* side must be —0.5 and hence the curve drops down for a minus value from *j* to *k*. Similarly, it drops twice as far from *l* to *m*, since $B = +1$ and therefore the other side of the *B* coil or *B'* must $= -1$. Following the curve in this manner to *n* and *o*, it completes one cycle or one north and south pole. The north pole is considered as that part above the horizontal reference line and under the line *g*, *h*, *i*, *j*, *k* and *l*, which is shown shaded, and the center of this north pole is indicated by the vertical arrow.

In an actual machine the magnetic field would not have such sharp corners, but would be smoothed out by the rotor winding into a smooth curve practically a sine curve such as the current curves in Fig. 1, but for purposes of illustration the "stair-step," or square-shouldered curves, may be considered as shown. In a similar manner the little stair-step picture may be drawn for each position and the center of the north pole marked by an arrow pointing up as shown. After drawing seven positions, the very interesting fact may be noted that the center of the north pole has traveled three slots to the left, which in this case means 180 electrical degrees, or a half revolution on a two-pole motor, or a quarter revolution on a four-pole machine.

Fig. 10 is drawn to show the effect of interchanging the leads to the coils *A* and *C*, or in other words, the line lead that was connected to *A* is now connected to *C* and vice versa. For this reason in the little sketch at the top of Fig. 10, taken from Fig. 8, and *C* coil is now in slot 1 and the *A* coil is in slot 3, the *B* coil remaining in slot 2 unchanged. The numerical values of the currents are again taken from Fig. 3 just as it stands, because it must be remembered that the curves in Fig. 3 represent currents in the line and that they depend on the generator and are not changed by the change in the motor leads. These assumptions give the current values for the different positions, as shown in the left-hand column in Fig. 10, and the small stair-step pictures show the magnetic field in the same manner as in Fig. 9. The interesting thing to note is that the center of the north pole has now traveled from the center of slot 3 to the center of slot 6, or the magnetic field has now traveled three slots to the right, which discloses the well-known fact that interchanging two leads on a three-phase motor will reverse the mechanical direction of its rotation. As a problem the reader might attempt to produce the same result for a two-phase motor and will find, as previously pointed out, that this field plotting becomes a fascinating mental diversion.

A comparison of Figs. 2 and 3 shows at once why the middle leg of a three-phase wnding is reversed in all the diagrams that have been shown in this series. Figs. 9 and 10 show how the magnetic field may be studied and how reversal follows exchange of two leads. This brings the discussion up to the point mentioned in the last article, of studying the effect of chording and reconnecting for a different number of poles, which will be shown graphically in the next article.

Difficulties of Plant Inspectors Similar to Those of Sanitary Inspectors

The work of the power-plant inspector, be his authority from the Federal, state or city government, if his efforts are directed toward procuring better results in the use of fuel, may be likened to that of a health officer or physician. He may not and probably cannot restore a "sick" plant to perfect health instanter. He probably will not be able by mere suggestion, if he had no power to go farther, accomplish more good than can the doctor with an unwilling patient. The plant that is in the worst of condition affords, of course, the best opportunity for improvement and "a showing" and should not be abandoned, any more than the other kind of patient, if its operation must be continued.

The day of the erstwhile "smoke inspector" perched at some point of vantage with binoculars in play, checking off smoke emissions from stacks in view, with unholy glee piling up fines against them, is everlastingly past. Smoke abatement is recognized as the result of improved combustion conditions to be attained by the aid of the inspector rather than in fear of fines assessed at so much per smoke.

In common with the health officer the plant inspector sometimes receives scant courtesy and little assistance from the "patient" or those who should be vitally interested in the case. The easy explanation in the first instance, given by those who consider themselves superior, is *ignorance*. What is it in the case of the plant manager? It would seem harsh to apply the same term to the manager in his well-appointed office, as to those living in filthy squalor. Coöperation with the inspector in either case is, however, often difficult to secure.

Confidence in the motives and wisdom of the inspector is of prime importance, and the experience and training in diplomacy of the successful sanitary officer are well worth applying in the case of the plant inspector. Both are engaged in a praiseworthy work and are deserving of encouragement in their difficult tasks.

Reasonable Charge for Off-Peak Electric Current

DURING the nonheating season the isolated plant is wasteful because it has no use for the heat in its exhaust steam. If it could purchase current from a public utility company at a reasonable rate during this period, fuel would be saved, the isolated plant would benefit and the public utility company would profit by having a better load factor. This is the stand taken by Percival R. Moses and many other engineers.

On Aug. 9 the Public Service Commission for the First District of New York held a further hearing in the case of electrical corporations' service and rates to buildings containing private power plants, at which Mr. Moses explained what he considered a reasonable charge for off-peak current furnished by the central station to the isolated plant, as follows:

The facts before the Commission are that during half of the year, except for sudden storm peaks, there is available at all times about 50 per cent. of the electric company's capacity. Mr. Lieb has testified that this capacity, however, does not constitute available capacity because sudden storm peaks taken in connection with repairs being made to generating apparatus at main stations reduce the apparently wide margin available for off-peak load service. In view of the definition I propose to make of off-peak load service, these objections are not valid, for the following reasons:

First, storage-battery capacity is provided which would take care of any storm peak. It has taken care of a large part of the total load in the winter months in the past when several turbo-generators blew up.

Second, if an off-peak load was available, a little foresight would plan that repairs should be made to the main station apparatus so as to leave capacity available for the off-peak load. That this is the case is evidenced by the fact that in Chicago and other cities, such as Richmond, Boston, and Milwaukee, off-peak rates are given to encourage such load. In any event, the repairs to the station apparatus affect only a very small part of the investment. The buildings, boilers, smoke-stacks, switching apparatus, real estate, transmission and distributing lines, subways, substations and their equipment and the batteries are all available for off-peak load even if two turbo-generators happen to be under repair. In addition to this, every public utility company in a growing community has to provide for increased load from year to year; hence, additional apparatus would be installed to take care of the winter peak for the following winter, and this apparatus with proper foresight could be installed any time so as to be available for the summer load.

Third, to provide for extraordinary instances, such as the simultaneous breakdown of two or three turbo sets or the burning up of a substation, it is proposed that off-peak service rate shall contain a provision allowing the public utility company to discontinue such service on reasonable notice.

It is contemplated that the public utility company shall be called upon to supply service only when it has available capacity for such service. Generally, this means that it may be called upon to supply service at any time during the day or night except the hours from 4 to 10 p.m. during the months of November, December, January and February. Should, however, occasion arise which reduces the capacity of the public utility company, either through breakdown or unusual conditions, it shall have the right by reasonable notice to require the private-plant operator to start his plant and supply all or the major portion of the electricity he requires.

Reasonable notice ordinarily would be three days from the time of receipt of notice. Should the public utility company be short of apparatus due to repairs or other causes during the summer months, it should have the privilege of notifying off-peak load consumers one week in advance that such consumers should hold themselves in readiness to start at two hours notice by telephone. It will probably be found in practice that such notices will not be given, as the public utility company will find the off-peak load of such value as to make its conservation of great importance, and it will consequently do everything in its power to make such contract satisfactory to the consumer.

The compilation prepared by the Public Service Commission showing the operation of the New York Edison Company for 1917 gives the various items entering into the cost of production and delivery of electricity. These items are as follows:

	Cents per Kw.-Hr.
Production expenses	0.967
Transmission and electric storage	0.094
Distribution	0.246
Commercial utilization	0.165
Municipal street lighting	0.043
Commercial administration	0.139
Promotion of business	0.159
General expenses (excluding depreciation)	0.348
General amortization	0.213
Uncollectible operating revenue	0.017
Tax accruals	0.417
Total	2.808

In consideration of the proper rate for off-peak service the effect of off-peak load on each of these items must be considered and a correct proportion allocated.

1. The production expense is 0.967 c. per kilowatt-hour sold. As the kilowatt-hours sold amount to only 74 per cent. of the kilowatt-hours made, and as the losses are greatest during the heavy-load periods, it is evident that the average cost of production per kilowatt-hour sold is higher than the average cost per kilowatt-hour of the additional electricity required by off-peak users, as this electricity will all be delivered during light-load periods.

In view of the difficulty of ascertaining what differences there would be due to this condition I have taken the average cost of production as being the cost of production chargeable to off-peak load.

2. The items of transmission, storage and distribution expense depend entirely on peak-load conditions and would not be increased by the off-peak load. Hence, no charge for these items should be made against the off-peak load.

3. The items of commercial utilization, commercial administration and promotion of business would be less per kilowatt-hour for off-peak load consumers than for average consumers because off-peak load consumers are all wholesale consumers having a single meter, or at the most two meters, and having engineers to take care of their own repairs of fuses, etc.

In the Ewoldt case against the New York Edison Com-

pany, Mr. Lieb gave two tables showing the comparative cost of supplying all consumers and the special wholesale consumers. In these tables he estimated the utilization and commercial expenses for the special wholesale consumers at 7 per cent. of the average. I have taken 10 per cent. as a fair basis and am therefore charging the off-peak consumer with 10 per cent. of the sum of 0.165, 0.139 and 0.159. The charge, therefore, against off-peak load consumers for the three items of commercial utilization, commercial administration and promotion of business is 0.0463 cent.

4. In the same case Mr. Lieb estimated the general expense at something less than half of the average. I have taken one-half as a fair basis for off-peak load consumers, making the charge in this case 0.174 cent.

5. As substantially no investment will be required for off-peak consumers, there should be no charge for amortization.

6. For uncollectible revenue I have taken the same figure as the average, which is 0.017 cent.

7. In the tax accruals, an analysis of the basis of taxation and the amount of taxes charged shows that out of $2,519,755.44 charged to income, $647,317.69 was due to land and improvements on land, real estate in New Jersey and tax on capital stock. These items are clearly due to the investment and vary with the maximum demand. I have therefore taken as the tax accruals chargeable to the off-peak load, three-fourths of the average cost per kilowatt-hour, plus half of the balance, or seven-eighths of the total. In other words, I have figured that instead of 0.417 c. per kilowatt-hour (being the average amount of taxes per kilowatt-hour) the amount which should be charged against the off-peak load consumers is seven-eighths of this sum, or 0.36 c. This makes the total cost, exclusive of rental and interest, as follows:

	Cents per Kw.-Hr.
Production expense	0.967
Transmission, storage and distribution	0.000
Commercial utilization, commercial administration and promotion of business	0.0463
Municipal street lighting	0.000
General expenses	0.174
Amortization	0.000
Uncollectible revenue	0.017
Tax accruals	0.360
Total	1.5643

To this I added 0.56 c. to cover a reasonable share of the subway rental, interest and dividends. This last item is obtained by adding up the items as shown in the Public Service Report and dividing by 603,000,000, which is the total amount of kilowatt-hours sold during the year. This makes the total price 2.12 c. per kilowatt-hour and this, in my opinion, is a reasonable price for this service, as it will yield a profit to the company of at least 0.5 c. per kilowatt-hour, which is 33⅓ per cent. of the cost.

At the conclusion of Mr. Moses' testimony, there being no further evidence submitted, the case was declared closed.

The Attleborough Branch R.R. and Interstate Consolidated Street Ry. has filed with the public service commission a notice of increase of fares, retaining the 5c. minimum charge, but increasing the number of zones in which the 5c. will be charged. Three local fares will be increased 100 per cent. and three 50 per cent. A gain in revenue of $46,500 a year is expected from the increase, enabling the companies to pay dividends which on the Interstate had ceased since 1915.

Brushes Were Shifted

A fact that is well known to most operators is that a shunt-wound generator will not "pick up" its field unless the shunt winding is connected to the machine terminals in the correct polarity relationship. Therefore, about the first thing to do when a machine fails to generate, unless the history of the machine suggests otherwise or unless another irregularity is evident, is to reverse the shunt-field connections or, for test purposes, to shift the brushes one pole pitch.

A shunt-wound generator had developed sluggishness in picking up its voltage, and from the fact that sandpapering the commutator would temporarily help conditions, it was concluded that the trouble was due to high mica in the commutator. Inspection and the moving of two brushes along the brush studs onto a commutator zone that had not been tracked by the brushes confirmed the diagnosis, because, after the shifting, the voltage came up at once and without sandpapering of the commutator. The chief showed a careful assistant how to slot the commutator with a piece of hacksaw blade provided with a tape handle, and the man made an excellent job of the slotting. Everything was all right when he finished except that the generator refused to generate at all. Not even sandpaper would help matters. After fruitless efforts to locate the new cause of trouble—and the peak of the load was due in an hour—the field of the machine was separately excited from another machine. Under this excitation, the voltage came up, but not to full value, because it was necessary to remove the excitation on account of vicious sparking of the brushes.

The second cause of trouble was that the slotter had shifted the brush rigging over in order to get the holders out of his way and forgotten to shift it back.

The Chicago Turbine Wreck

Few details of the accident to the 35,000-kw., 25-cycle, 1500 r.p.m., single-cylinder turbine in the Northwest station have reached us up to date. The following is, however, illuminating:

This machine, one of the new ones to be installed in the plant, and one of the latest types to be brought forth by the General Electric Co., was being given a test to make sure that the overspeed automatic stop governor would function at the usual 10 per cent. above normal speed. This was done, as usual, immediately after the load had been taken off the machine; the time was 12.22 a.m., Wednesday, July 31.

Our information is that the speed during this test was such as to give but 26½ cycles, or less than 10 per cent. over normal speed, when there was commotion within the casing, violent vibration, then bursting of the low-pressure casing and release of pieces of diaphragms, blades, etc. into the turbine, through the roof and against the walls on both sides of the room, and through the glass front of the switchboard gallery. The entire unit, except for the main generator and possibly the shaft and most of the wheels, is said to be completely ruined. Presumably some of the blades on the last two low-pressure wheels first let go from their fastenings, jammed and thus caused the demolition of the machine.

We hope to present further particulars in another issue.

EDITORIALS

President's Proclamation to Coal Workers

THAT the prosecution of the war is in danger of being greatly retarded because of the lack of coal production has been emphasized by President Wilson, who, in a recent proclamation to all of those engaged in coal mining, has sounded a warning to producers of coal, miners and operators alike, that the prospect of a coal shortage for the coming winter is serious.

That there is occasion for the deepest concern regarding the coal situation is made all the clearer, inasmuch as the President finds it advisable to take the matter in hand and make an appeal to all those engaged in the production and handling of coal. In his proclamation, President Wilson urges the mine operators to be zealous as never before to bring about the highest efficiency of management, to establish the best possible working conditions and to accord fair treatment to everybody. He urges the miners to work every day and to stay in the mines full time, and to bend every endeavor to get out more coal than ever before. Other workmen about the mines are urged to work regularly and faithfully so that the work of the miners may not be retarded in any way.

Mining coal, like any other industry, depends largely on team work if the maximum output is to be obtained. It would be useless for the miner to work full time and to get out a maximum production of coal if it were to become clogged at the bottom of the shaft or entry because the hoist or haulage engineer does not keep the loaded cars coming to the surface as fast as the miner can fill them. Then the duty of the outside men is to dump the loaded cars and keep a stream of empties going back into the mine.

When the miners and the other workmen do their part in getting the coal to the tipple it is the duty of the transportation line to produce empty cars for loading and to haul the loaded railway cars to their destination.

One may casually wonder why there should be a shortage of coal. This is easily explained in that many mine workers have enlisted, others have entered other branches of industry, full time is not put in by those who are at work and there is more or less of a car shortage. Added to these reasons, more coal is being consumed than formerly.

The greatest demand for coal is at war-supply and munition plants. The steel works have been running at maximum capacity to meet the requirements of the factories manufacturing cannon and shells to be used by the American soldiers across the water, and these mills are consuming about twice the amount of coal normally required. Not only is it necessary to fill the demands of war industries, which have increased by leaps and bounds, but there are the needs of the Government to meet. The demand by the Government of coal for the Navy has increased something like one hundred and fifty per cent. during the past month alone, when about six million tons of coal were required, and it is estimated that by the end of the year the coal requirement to meet the Naval demands will reach close to eight million tons.

Many new war industries have started up, or are about to do so, since the coal shortage of last winter, and these will require thousands—yes, even several additional millions—of tons of coal over the former demand.

The President's proclamation is timely; the needs of the country are urgent; team work of all those who have to do with coal production and handling will give the results urged by our President.

Mechanical Originality

THERE exists no precise definition of originality. It is, of course, on record that there is nothing new under the sun, yet invention which receives the cachet of letters patent is always at work. The Patent Office itself does not pretend to define the term, only to hedge it round with qualifications. To be peculiar is not to be original, while ingenuity, the word from which engineer is derived, does not bear the interpretation original. In a human sense too great a divergence from the normal has been honored by special means of restraint whereby peculiar people are segregated. To be different is not to be original. Diversity of thought and opinion and difference in human type are some of the vital things which make life itself interesting and add charm to mechanical art. Originality has a happy knack of evading academic conclusions; it is the inventor, the genius, who achieves regardless of settled ideas.

In general, originality is a relative term—it is possible to be original only by comparison. Revolutionary discoveries are few and the names of the men responsible are household words. The opportunities open to the average practitioner of mechanism are limited to a small orbit.

Standard practice is part prejudice, part conservatism, part imitation, but does get interlayered with a proportion of new ideas. It is the incidence of this latter which repays investigation.

The patents granted during any period of time serve to show that there is a common atmosphere dependent upon some external stimulus which groups invention. This is as it should be, for invention is more evolutionary than revolutionary save in a very few outstanding instances.

There is a period in the working life of every mechanician when he consciously strives to be original; every mechanic worth his salt has endeavored with some measure of success to aid mechanical evolution. One curious fact is that men who have done original work were unconscious of the fact until later; they did the best they knew. Faced with some difficulty or problem, by

patient disentanglement they solved it; every such piece of work, whether detail or main design, is an original feat. Yet originality in its highest form is something more. The man who adds a new conception to human ideas, mechanical or otherwise, does not usually set out to be original; he sets out in the spirit of high endeavor to do good work, to do the best he knows how. The resultant, never attained in a flash, is part inspiration, but the greater portion hard and tedious work. To be original involves superior intelligence, but this is by no means uncommon. The designer who consciously strives to be original is likely to be dangerous: great divergence must entail more than usual justification; otherwise it is difference without reason.

Original conception is rare; most mechanism is permutation of old idea to new utility. Evolution of every kind proceeds tentatively and is evidenced by failures, discards and blind ends. There is such a thing as mechanical instinct, itself the product of digested experience and natural aptitude which rarely misleads. Those who possess it are among the elect, for while they seek after a new idea they combine it and judge it by practical standards. Originality is valuable precisely in proportion to the end it serves, for unless inversion is justified by results wherein lies the need for difference?

Let There Be No Industrial Slacking

THE wonderfully encouraging news from the Western Front must not be allowed for a moment to blind us to the immense importance of keeping "on the job" as though the war were going to last a hundred years. This is no time to chase the rainbow of peace. No worse misfortune could befall the United States at this juncture than that its people should let up on their war activities. A certain amount of peace talk has begun to go the rounds in different parts of the country, based on the terrific blow Marshal Foch has dealt the Huns in the Soissons-Rheims salient, but the enemy is not yet defeated, and while time will doubtless show that we have passed the turning point in the war, the only safe policy now is to renew every possible effort to carry the fight to final victory.

This means that there must be no relaxation in the building of ships, manufacture of guns and munitions, construction of great war terminals and bases, development of aircraft power, provision of boilers and engines for the merchant marine, the navy and the industrial power plant, no sagging off in Red Cross and related activities or easing up of the strain in the production of coal, operation of railroads and public utilities, or any other of the branches of war work with which our country is now literally humming. We must still be prepared to work overtime cheerfully; to forego holidays if it is necessary to complete some important piece of war work on a given date; to redouble our efforts to eliminate waste of fuel, labor and supplies of all kinds, and to carry on the tasks of young men withdrawn from industry to serve in the army or navy.

The time has not yet come in sight when the older executives and engineers can relinquish the self-imposed duties many of them have taken upon their shoulders in the absence of assistants formerly depended upon to bear the routine burdens and handle the more onerous physical responsibilities and drudgery. A great deal of credit should be given to these older men who have stepped into the breach and donned the close-binding harness of their younger days in whole-hearted effort to do their utmost in every way to carry the industrial life of the country onward to victory. Let none of us make the mistake of overestimating the meaning of the glorious achievements of our soldiers, sailors and Allies within the past few weeks; although the dose they have been giving the unspeakable Hun is a fair sample of what is coming to him later on! Let none of us play the enemy's game by relaxing for a moment our endeavors to smash down the power of autocracy once and for all. Great as is the Allied victory, it does not mean immediate peace, and every loyal American from the most humble water-tender to the President is thinking day and night of war and war only.

Federal Boiler Inspection Act

THE Federal Boiler Inspection Act, enacted by Congress in 1911, making it unlawful to use steam locomotives in interstate commerce unless the boilers are in proper condition and have been inspected and tested, is a "statute enacted for the safety of employees," within the meaning of the Federal Employers' Liability Act, declaring that an injured employee shall not be deemed to have assumed a risk of injury arising from his employer's violation of a statute enacted for the safety of employees. This point has been established by a decision of the highest court in the land, handed down in the late case of Donaldson vs. Great Northern Railway Co., 38 Supreme Court Reporter, 230.

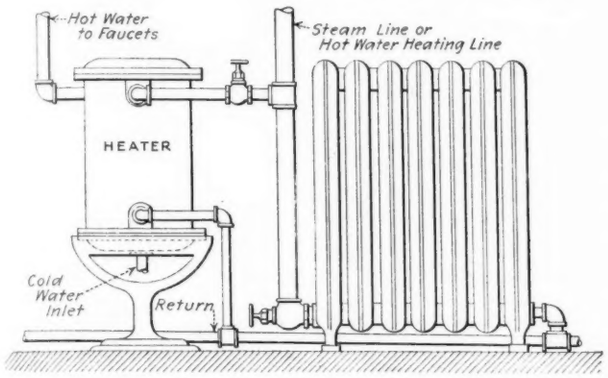
Other points decided in this case, in which judgment in plaintiff's favor on account of the death of her husband, a locomotive engineer, in an explosion of a locomotive boiler is sustained, are that the evidence was insufficient to show that Government inspectors had approved the use of the large type of button head on the crown-bolts of oil-burning engines, and that a railway company is not exonerated from liability for the explosion of a boiler because an unsafe feature of construction to which the accident may be directly attributed was not disapproved by the Federal boiler inspectors.

Accidents at metallurgical works in the United States during the calendar year 1916, according to the third report of the Bureau of Mines, compiled by Albert H. Fay, show a gratifying reduction in fatalities at both smelters and ore-dressing plants. The nonfatal injuries show an increase, caused not so much by an increasing hazard as by the more complete returns received. The figures cover the returns from 150 smelting plants and include copper, lead, zinc and quicksilver smelters, as well as refineries. Iron blast furnaces are not included in the figures given. The ore-dressing plants represent concentrating plants for copper, lead, and zinc ores, stamp mills, cyanide plants and iron-ore washers. The total number of men reported employed in the metallurgical plants, both smelters and ore-dressing plants, was 66,194, as compared with 49,891 in 1915, and 43,007 in 1914. The number of fatalities reported was 83 at metallurgical plants, 33 at ore-dressing plants, 36 at smelters and 14 at auxiliary works, including shops, yards, etc. The number of nonfatal injuries reported was 15,080.

CORRESPONDENCE

Hot-Water Service from Heating System

Supplementing the reply to G. H. J. at the bottom of the "Inquiries of Interest" page in the issue of Mar. 19, I believe it will be found advantageous in some cases to connect a closed water heater with the heating system, circulating the heating agent (steam or hot water) through the heater. By using a proportionately large storage capacity for the hot water, no sudden demand will be made on the heating system when water is drawn. The illustration shows how a water heater was connected in one case. WILLIAM WILCOX.



WATER HEATER CONNECTED TO HEATING SYSTEM

Philadelphia, Penn.

Worth-While Economies

We have all heard the expression that "a little knowledge is a dangerous thing," but it is sometimes the means of making us ask questions and perhaps starting a profitable discussion. I hope that the following will fall within the latter class and that readers of *Power* will take up the subject of over-all efficiency of a plant vs. ultra efficiency at one point to the detriment of some other.

A case in point is our own turbine plant operating at 150 lb. steam pressure, superheated to about 575 deg. F., or about 200 deg. superheat. The economy, based on the steam consumption at the turbine, is good, but under some conditions and with the variable load we are obliged to handle, an excessive amount of makeup water has to be used—city water paid for by meter, costing real money—and the temperature at which it is fed to the boilers is lower than it should be, so that the economy gained at the turbine is somewhat lost in the boilers. The trouble and expense from high steam temperature also tend to offset the saving by its use. These troubles manifest themselves in the form of difficulty in sealing steam glands, the continual expense in renewing the packing and after all the impossibility of keeping stuffing-boxes steam-tight.

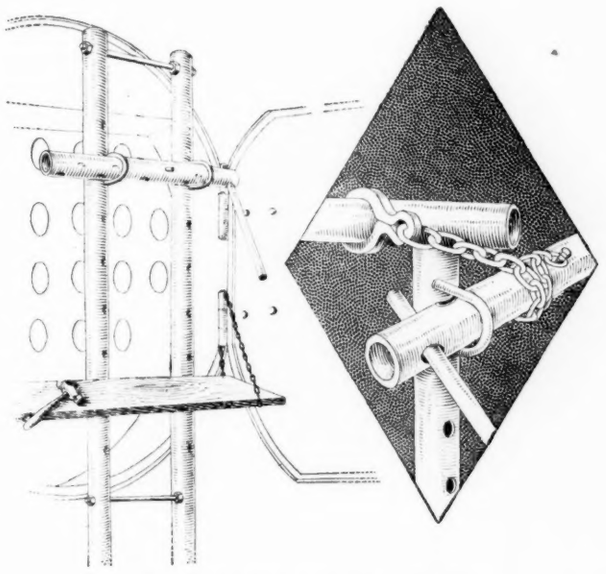
There are numerous other operating difficulties, with which users of high superheat are familiar, so that it seems to me that there must be something to be said in favor of a lower degree of superheat. It would be both interesting and profitable to have the subject thoroughly discussed. J. W. CARRUTHERS.

Stellarton, N. S., Canada.

Capstan for Pulling Boiler Tubes

A convenient and simple tube puller, easily made from pipe, is shown in the illustration. The best length, width, etc., depend upon the style and height of the boiler breeching. The uprights in this case are 7-ft. lengths of 3-in. pipe and $\frac{11}{16}$-in. holes are drilled from 4 to 6 in. apart to take U-bolts, as shown, to support the cross-pipe, which is also drilled with numerous holes at random to receive a steel bar.

The crosspiece is first set just below the level of the tube to be removed. The tube is cut loose at both ends and driven out as far as possible with sledge and bar. A chisel or drift pin is then driven into the tube and the pulling ring slipped over or a "half-hitch" is taken around tube end with a chain. The chain is then tightened and wound a few turns around the crosspiece and attached to it with a stud. With the bar inserted in the various holes, the rig acts as a capstan or windlass, so that the tube is soon withdrawn.



TUBE-PULLING RIG IN POSITION

To those fortunate enough to live in districts where there is good water, this rig might seem to be a monstrosity, but where bad water abounds and the tubes are scaled up badly and it is a day's task to remove a few, it is a mighty good thing.

Calumet, Mich. R. E. MCNAMARA.

A Convenient Testing Outfit

We have in our plant a testing outfit similar to that shown in the figure and find it one of the most useful appliances in connection with electrical repair work. It consists of a double bank of lamps, which are connected through the copper terminal *E*. The lamps, being in multiple, burn at full candlepower when the circuit is completed through the test lead *E*.

A snap switch *D* is used for turning off half the lamps to vary the strength of the current. Terminals *E* are

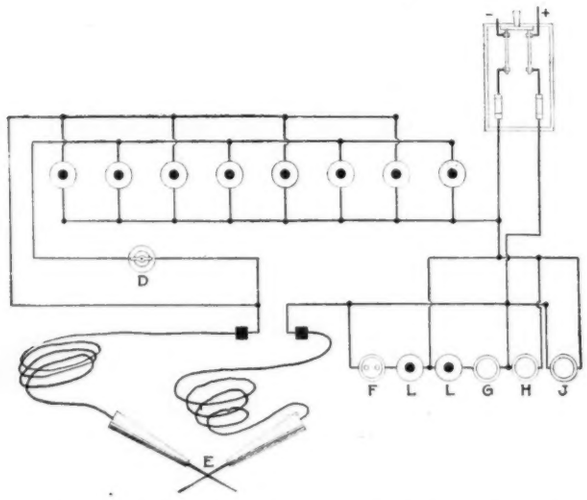


DIAGRAM OF TESTING EQUIPMENT CONNECTIONS

used in testing for grounds, short-circuits, continuity of circuits, testing all kinds of fuses, or to try the setting of spark plugs, etc. *F* is the base of a divided attachment plug and *G* a socket for testing extension cords connected to attachment plugs. The sockets are in series with a lamp *L*, which serves a double purpose. First, it prevents blowing fuses if the extension cord being tested is short-circuited, and second, if the cord being tested has no lamp in its socket, we simply short-circuit the socket and the lamp *L* shows if the line is continuous. If the cord is already short-circuited, the lamp will show without short-circuiting the socket.

If there is a lamp on the end of the extension cord and the line is all right, the two lamps will light at half brilliancy. If the cord under test is open-circuited, both lamps will remain dark, or if short-circuited, the stationary bulb will light and the other will not. One lamp socket *H* is used for testing lamps and is connected directly across the line. The threads are flattened out in this socket so that the lamps can be slipped in and out, thus saving time screwing the lamps in and out. A lamp socket *J*, also connected across the line, is used for attaching drills, lights, etc., for work about the bench.

J. M. WOODRUFF.

Toledo, Ohio.

Protecting Blowoff Pipes

The blowoff pipes from the return-tubular boilers in this plant were all protected from the direct action of the fires by corded asbestos closely wound about the pipe. This was a relatively cheap method at pre-war prices, but it became necessary to replace the covering on one of them lately, and as the management did not care to buy more of the same material at present prices, it was up to the chief to devise something different.

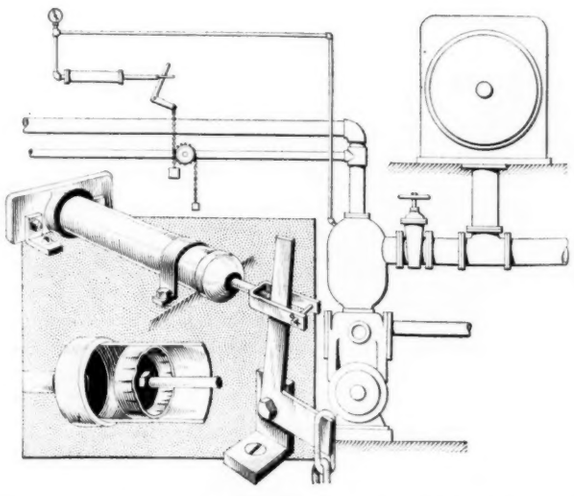
First, we wound wire around the pipe, then made up a plaster of two parts of fireclay and one part of old asbestos pipe covering pounded to a pulp, and mixed to the right consistency with a saturated solution of salt water. This was applied with a trowel over the wire. This has proved a better method than the previous one and is considerably cheaper. This kink is perhaps not as novel as it is useful.

Los Angeles, Calif. GEORGE F. SKELLY.

Falling Weight Opens Valve

I have devised something that I believe others will be glad to know about. When running condensing with a single jet pump taking water from a stream or river, leaves and other floating material will sometimes clog the suction-pipe strainer, or the pump will get "tired" and stop. We have a little of both, and of course the steam does things to soft-rubber valves before you can get to it to turn on city water. I studied the thing over quite a lot before I decided on adopting the rig here described.

I bought a single-cylinder tire-inflating pump and put new cup leathers in, but in the reverse position from that when used as a pump. I connected it up as shown in the illustration, by drilling and tapping a hole in bottom of tire pump for a ¼-in. pipe and connected it to the pipe that runs to the vacuum gage. Then I took the handwheel off the 2-in. city-water supply valve and put a 6-in. sprocket wheel in its place and got about eight feet of old sprocket chain to match. I next attached a weight heavy enough to open the valve, with a



WHEN VACUUM FAILS WEIGHT FALLS, OPENING VALVE

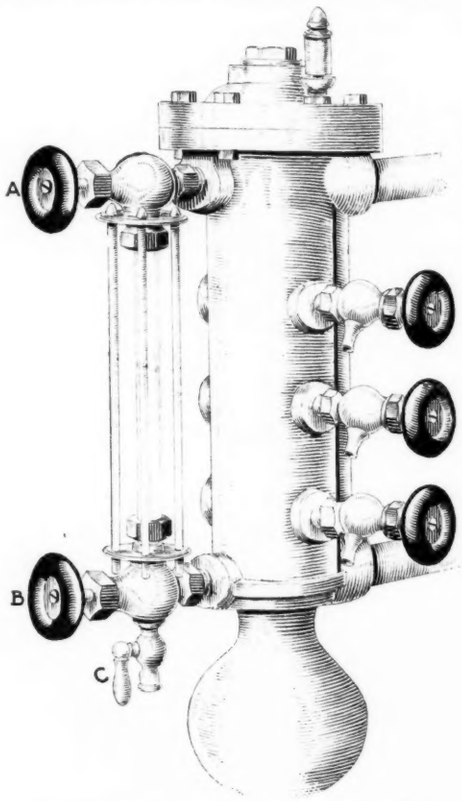
small weight at the other end to keep the chain from jumping off.

The piston rod of the air pump is then connected to a bell crank or trigger having leverage enough over the weight to hold it up as long as there is a vacuum within the tire pump, but it will drop the weight and open the valve when the vacuum breaks. It can be regulated to act at any desired degree of vacuum.

Winfield, Kan. J. C. HILTON.

Clearing Gage and Water-Column Connections

The valves on a gage-glass are usually left wide open when "blowing out" at *C*, but steam, being quicker than water, does most of the blowing, so that the lower connection may be partly clogged and sluggish. I have found that by closing valve *A* and blowing through *B*



CLOSE VALVE *A* WHEN BLOWING DOWN

alone this dangerous condition may be eliminated. The same conditions exist in the column proper. The laws in some states do not permit the use of valves on water-column connecting pipes, hence, when the blowoff is opened, the lower line does not get thoroughly cleared.

Philadelphia, Penn. T. A. MARSHALL.

Gas Formed in Engine Piston

A somewhat unusual experience was met with in drilling out a dowel pin in the hollow cast-iron piston of a 24 x 36-in. engine. The engine was still pretty hot as it had just been shut down and the piston withdrawn far enough to remove the first ring and drill out the stub of the broken pin. When the nose of the small drill first broke through into the cavity of the piston, a hissing sound was heard, and on withdrawing the drill a jet of some sort of combustible gas shot out and was ignited by the torch that had been set on the steam chest probably two feet away, and the gas flame extended fully three feet from the piston.

The performance lasted only "a little minute," of course, before the gas was exhausted, but was quite a surprise meanwhile. It was a matter of considerable speculation as to how the gas was formed within the piston—whether cylinder oil had penetrated through the pores of the iron or oil had been used pretty liberally or spilled inside the piston when tapping the sand core holes and then vaporized by the heat. The engine had been in use a number of years.

New York City. J. LEWIS.

Lightning Explodes Boiler

The accompanying view is of a boiler that exploded at a steam laundry at Baldwin City, Kan. The boiler is of the marine type, 8 ft. long and 3 ft. 9 in. in diameter. The large flue is 2 ft. 1 in. in diameter, and there are 25 3-in. flues. The large flue is made up of three sheets, $\frac{3}{8}$ in. thick, single-riveted lap joints. The shell is of the same thickness, but is made of a single sheet with a double-riveted lap joint. The boiler has no braces except two 1-in. rods that brace the flue sheets above the flues. This boiler has been in service less than a year, and was worked at less than 100 lb. pressure, although the safety valve furnished by the builders was set at 120 lb. and at times the pressure reached that point.

At the time of the explosion the boiler was carrying 80 lb. and had about 3 in. of water in the glass. The owner, who was in charge, had just stepped out when the lightning struck the boiler house and the explosion followed, blowing out both ends of the building and throwing the boiler about 70 ft. from its

BOILER AFTER THE EXPLOSION

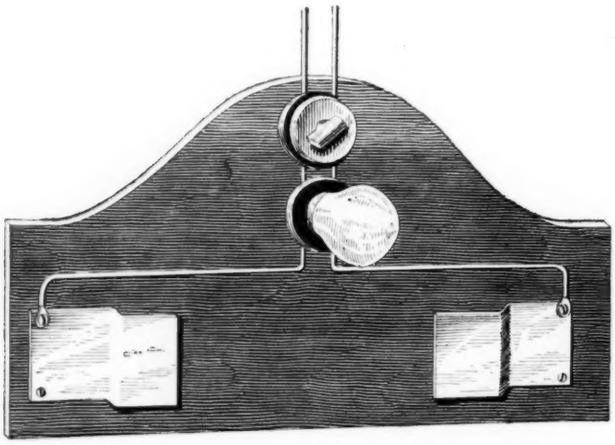
original position which is indicated by the white circle. The boiler was mounted on wooden skids and was not very well grounded and so made a fair mark for lightning. The top of the safety valve was blown off, and the large flue was ruptured at the back seam. Some of the rivets were pulled through the sheet and some sheared.

It would be interesting to know whether there are other records of boiler explosions due to lightning. Had it not been that two persons saw the lightning strike the boiler room, I would have doubted that this was the cause of the explosion. There was a whistle above the roof, and it is said that the lightning struck this whistle first.

Baldwin City, Kan. A. W. KIRBY.

Testing Cartridge Fuses

Having a lot of cartridge fuses to test frequently and finding it tedious work by the old way of ringing out with a magneto, I got up the rig illustrated and put it up permanently in a convenient place and find it a great help. I use two pieces of brass set opposite each other as



CONTACTS FOR TESTING CARTRIDGE FUSES

contacts. The lamp is connected in series, and when the fuse is put across the contacts, if good, it will close the circuit and the lamp will light, but if it is bad, the lamp will not light as the circuit will still be open. Other contacts can be arranged for testing plug fuses and lamps in the same way. B. DAN DE PASS.

Hudson Heights, N. J.

A Peculiar Case of Pipe Stoppage

An unusual case of corrosion has come to my knowledge through the failure of a pressure gage to properly indicate the pressure in the pipe to which it is connected. I disconnected the ¼-in. line leading to the gage and found that it was entirely stopped up. By using a wire to locate the place of stoppage, I discovered that it occurred at a point where a lamp cord from a 110-volt alternating circuit was twisted around the pipe. The pipe was filled up solid for about three inches, while the rest was clean and uninjured. It is a question whether the solid matter is corrosion or some magnetic mineral collected from the water by the action of the current around the pipe. A. C. FRENCH.

San Angelo, Tex.

Municipal Lighting Plant

I have read the discussion of the municipal-plant movement on page 19 of the July 2 issue of *Power*, and I notice therein the statement that about one year ago the Kansas City Light and Power Co., in order that it might have a return of 6½ per cent. was granted an increase in rates by the Missouri Public Service Commission.

I was with the commission at the time this case was tried and am familiar with the details, but I did not know until I read the article in *Power* that the result was an increase in the rates. As a matter of fact, the company made no application to the commission; the case was begun on the commission's own initiative because it regarded the rates charged in Kansas City unduly high and discriminatory.

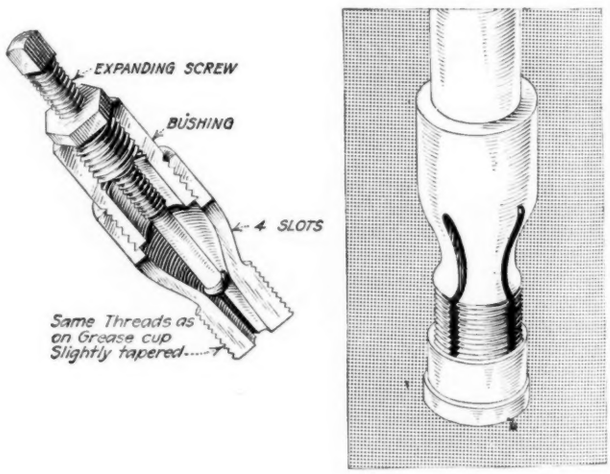
Regarding lighting rates for residences the commission ordered the maximum reduced from 11c. to 8c., the maximum for commercial lighting reduced from 10c. to 8c. and for power from 8c. to 6c. True, there will be no trouble in finding individual customers who are paying increased charges on account of the commission's order, but this is because of certain discriminatory contracts whereby some consumers were receiving unduly low rates.

If the statement in regard to the municipal plant in Michigan, which has increased its net profits 100 per cent. during wartime conditions, is no more reliable than the account of the Kansas City rates, it would be unsafe to draw conclusions therefrom. You say you are not familiar with the rates in that town or reasons why the net revenue was increased. The article in question would have had more value if these facts had been determined. J. A. WHITLOW.

Jefferson City, Mo.

Straightening Damaged Grease-Cup Caps

The illustration shows a device I have found useful for straightening the caps of grease cups that have been damaged by being dropped on the floor or otherwise abused. This device can be made in any plant having a lathe. A bushing is threaded on the inside for a nut, through which a screw passes, and on the other end it is threaded on the outside to receive the expander, which is bored out and reamed inside to a Morse No. 2 taper and threaded on the outside with a slight taper to a loose fit inside the cup cap. Slots are cut with a hacksaw as shown. When a cap be-



DEVICE FOR STRAIGHTENING DAMAGED GREASE-CUP CAPS

comes damaged, it is screwed to the expander and the expanding screw tightened, spreading the expander inside the cup. By tapping it lightly with a hammer handle or soft hammer, the cap can be restored to its original shape. The same bushing and screw can be used for any number of expanders for the different sizes of grease cups in use. D. B. VAN METER.

Covington, Ky.

INQUIRIES OF GENERAL INTEREST

Inferior Economy of Smaller Engines—Why are large engines more economical of steam required per horsepower than smaller engines? W. B.

The principal reasons for lower economy of smaller engines are the larger proportions of clearance spaces and losses from radiation of heat, leakage, condensation and friction.

Dampening Pulsations of Pressure on Pump Governor—How can the feeder line that connects a pump governor with a water-pressure line be relieved of hammering and pulsations from the pressure line? T. E. R.

The pulsations usually can be prevented by partly closing a valve in the feeder line. Where the feeder line is short and without benefit of elasticity of volume, the pulsations can be dampened by connecting a corrugated metal bellows to the line to obtain an air-chamber effect.

Power Developed by Engine—If the initial cylinder pressure of a 16 in. x 24 in. engine running at 100 r.p.m. is 120 lb. and the ratio of the m.e.p. to the initial is 0.45, what number of horsepower is developed? S. F.

The m.e.p. would be $120 \times 0.45 = 54$ lb. per sq.in., and as the piston area would be $16 \times 16 \times 0.7854 = 201.06$ sq.in., the power developed would be

$$\frac{PLAN}{33{,}000} = \frac{45 \times 24 \times 201.06 \times (2 \times 100)}{33{,}000 \times 12} = 109.6 \ I.hp.$$

Evaporation per Pound of Coal—What evaporation per pound of coal is obtainable in boiler practice? J. L. L.

The evaporation depends on the quality of fuel, perfection of combustion and efficiency of the boiler. With a good quality of coal the maximum theoretic evaporation would be about 15 lb. of water evaporated from and at 212 deg. F. per pound of coal. The maximum practice is about 12 lb.; excellent practice, 10 lb.; fair practice 8 lb.; common practice, in small plants, about 7 lb.

Advantages of Mechanical Stokers for Low Grades of Fuel—What are the advantages of mechanical stokers over hand firing for burning low grades of fuel? R. B.

In addition to saving in the fireroom labor, which is greatly increased by use of lower grades of fuel, better results are usually to be obtained by a mechanical stoker, as it carries a cleaner fire, the coal is fed more uniformly and the air required for the combustion is supplied at a more constant rate. It is difficult to prevent smoke when low grades of fuel are hand-fired, and by proper use of a well-designed stoker the smoke given off may be reduced or entirely prevented.

Testing an Anemometer—How can we test the accuracy of an anemometer used on a large draft system? The instrument consists of four hemispherical cups suitably mounted and geared to indicate the draft velocity. B. E. S.

Mount a radius arm in a horizontal position on a vertical axis. Make the arm of any convenient length to suit the room available for making the test. An arm 5 to 10 ft. long will be suitable. Attach the instrument to the end of the arm. Arrange its axis so that when the arm is swung in a circle, the vanes will pass through the still air in the proper way to rotate them. The test is made by carrying the instrument through the air at a known speed. If a five-foot radius is used, each turn will carry the vanes through $2 \times 5 \times 3.1416 = 31.416$ ft. Arrange to drive the arm at a uniform speed either by hand or by power. If the rate be 20 r.p.m., then $31.416 \times 20 = 628\frac{1}{3}$ ft. per min. is the air velocity that should be registered. Try different speeds and plot a curve of the registered velocities. Also, plot one for the calculated velocities and compare these curves to show the error of the instrument and the corrections to be made for different readings.

Making Evaporative Test of Heating Boiler—How can the rate of evaporation of a boiler be determined when the boiler is used solely for steam heating having all returns feeding back to the boiler? J. S. C.

The rate of evaporation should be determined in the same manner as for a boiler used for any other purpose; namely, by observing the temperature and weight of feed water evaporated per hour and quality of steam generated. The steam generated during such a test may be blown off through the safety valve or can be condensed in the heating system and the returns can be wasted or pumped back into the boiler. But the weight and temperature of the returned water, or of makeup water used, should be ascertained and for conclusive results the test should be made in this as in other respects in accordance with standard rules for conducting evaporative tests of boilers—such as those recommended by the American Society of Mechanical Engineers.

Foaming and Priming—What is the difference between boiler foaming and priming and what are the causes? W. R. L.

A boiler is said to foam if the steam space is partly filled with unbroken bubbles of steam and to prime if the steam carries water with it from the boiler. Foaming is caused by materials dissolved or suspended in the water that interfere with the free liberation of steam. A collection of scum on the surface of the water in the boiler caused by oil, vegetable matter or sewage may form a coating that forms bubbles, or when the water contains an alkali and any animal or vegetable oil becomes mixed with it, the alkali with the oil forms a soapy compound causing strong suds and foaming. Foaming may also be due to the concentration of certain salts in the water. Priming or carrying over of water may be caused by failure to blow down regularly and sufficiently; failure to clean the boilers regularly; presence of oil, alkalies or vegetable matter; carrying water line too high; insufficient steam disengaging surface; insufficient steam space of the boiler; and forcing the boiler.

Weight Required for Safety Valve—What weight of ball would be necessary for a 3-in. diameter lever safety valve to blow off at 100 lb. gage, where the weight of valve and stem is 5 lb.; distance from fulcrum of lever to center of valve 4 in.; weight of lever 9 lb., distance from fulcrum to center of gravity of lever 14 in. and distance from fulcrum to center of ball 22 in.? A. K.

The valve area exposed to steam pressure would be $3 \times 3 \times 0.7854 = 7.07$ sq.in. and for 100 lb. pressure per square inch the total force tending to raise the valve would be $7.07 \times 100 = 707$ lb. This would be balanced in part by the weight of the valve (5 lb.) and the force exerted by the weight of the lever. As the distance from the fulcrum to the center of the valve is 4 in., weight of lever 9 lb. and distance from the fulcrum to the center of gravity of the lever is 14 in., the downward pressure exerted on the valve by the weight of the lever would be $(9 \times 14) \div 4 = 31.5$ lb. and the net pressure required to be balanced by the ball would be $707 - (31.5 + 5) = 670.5$ lb. As the distance from the fulcrum to the center of the valve is 4 in. and the center of the ball would be 22 in. from the fulcrum, then for the valve to blow off at 100 lb. pressure per square inch the weight of the ball would need to be $670.5 \times 4 \div 22 = 121.9$ pounds.

[Correspondents sending in inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications.—Editor.]

Development of Power from the Standpoint of the Boiler Room*

By C. F. HIRSHFELD

Although only a small percentage of the latent energy contained in fuel is converted into electric energy and delivered to the consumer in the best of plants, there is comparatively little improvement to be hoped for in them; but there is a large and profitable field for betterment in the operating conditions of the "average" or the worse than average plant. Suggestions to that end are contained in the following abstract.

THE physical side of the life of civilized humanity is almost entirely dependent upon power. Power is responsible for the manufacture and distribution of all of the numerous things which are considered necessary to that physical life, such as food, clothing, housing, tools and equipment of similar sorts. Moreover, power is also very largely responsible for the development of the tremendous mental stature to which modern humanity has grown and, in one way or another, it is even responsible for the satisfaction of the most æsthetic cravings of the human animal. In short, modern mental and physical life and activity, when considered broadly, are built upon a basis of power. When properly interpreted, the power consumption per capita in any country may be used very safely as a measure of the development of that country, and the rate at which the consumption of power per capita increases, forms a very good measure of the rate at which the population of a country is developing.

Rapid Increase of Power Demands

Development of all sorts, physical and mental, has been astoundingly rapid in the United States during the past few decades and is continuing at an ever-increasing rate. This is reflected directly in the continued rapid increase in the amount of power used in this country. In the more active industrial centers the power demands have increased almost on a geometric scale, and at the present time the power demands of such communities are doubling in from three to six years. Moreover, because of the great economy and convenience resulting from the use of power in electrical form, a very large fraction of the total power consumption of this nation is electrical. Electrical power is now so universally available that, to many, power and electricity are synonymous terms.

Despite all the efforts which have been expended in the improvement of methods of generating electric power from fuel, the efficiency with which the latent energy of the fuel is utilized is still surprisingly low to those not familiar with the natural limitations of this method. There are few, if any, large centralized power systems in which as much as 12 per cent. of the latent energy of the fuel appears at customers' premises in electrical form, and there are many systems in which the consumers get less than 6 per cent. of the latent energy of the fuel. These figures seem appallingly low, but they are not bad when compared with what is theoretically possible. It is probable that an entirely new generating station equipped with most modern machinery, serving an entirely new distributing system, could be made to land at customers' premises from 16 to 18 per cent. of the energy of the fuel, and that is so close to the theoretical maximum that there seems little likelihood of greatly exceeding such figures unless radically new methods are developed.

A study of the distribution of the various losses that occur during the generation of power is particularly instructive. For this purpose the case of a modern coal-burning plant and a modern distributing system may be assumed, and the values obtained, representing about the best that can be done with equipment of such types, when operated continuously under the best conditions of loading; these values are shown diagrammatically as in Fig. 1. The boiler plant is seen to be fairly efficient, only about 15 per cent. of the energy of the fuel being lost at this point. On the other hand, the part of the plant in which heat energy in steam is converted into electrical energy appears to be woefully inefficient, converting into useful form only about 20 per cent. of the energy in the coal, or about 23.5 per cent. of the energy in the steam. The relatively poor performance at this point is unfortunately unpreventable. Thermodynamic laws set certain limits that cannot be exceeded and that are being approached very rapidly as the development of large turbo-generators continues.

The values given in Fig. 1 correspond roughly with the consumption of about 1.5 lb. of coal for each kilowatt-hour metered at customers' premises, and it should be understood that such a value could be obtained only if the plant were equipped with the best of modern machinery and if it operated continuously at its best load. Apparatus is in sight which under these conditions would probably reduce this figure to about 1.3 lb. of coal per kilowatt-hour at customers' meters, a value which is interesting in an abstract way, but which would be incapable of attainment because of the effects of commercial load factors. Under real operating conditions the consumers' demands for power fluctuate greatly during the various hours of each day and night, and they also vary characteristically on different days of the week and during different months of the year. As a result of these variations such operation as was assumed in determining the values shown in Fig. 1 is commercially impossible and a system which delivers at its customers' meters from 12 to 14 per cent. of the energy latent in the coal fired, ranks very high as an economical producer of power. This corresponds roughly to two pounds of coal per kilowatt-hour delivered to consumers. A registration at customers' meters of only 5 per cent. of the energy originally contained in the fuel was remarkably good performance less than a decade ago, and figures of this order are still characteristic of many central-station systems. It is not at all difficult to operate a system capable of deliv-

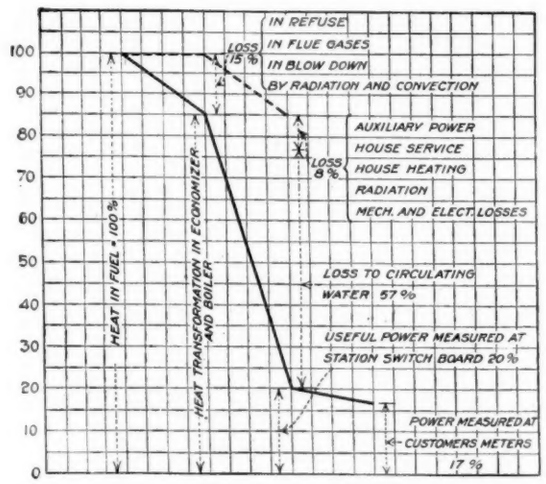


FIG. 1. VARIOUS LOSSES IN THE GENERATION OF POWER

*"J. E. Aldred Lectures on Engineering Practice, at Johns Hopkins University."

ering to consumers 12 to 14 per cent. of the fuel energy in such a way that only half of this amount is delivered. On the other hand, constant study and careful supervision are required if figures approximating the best possible performance are to be obtained day after day throughout the year. It must not be imagined that all the study and supervision are required at the power plant, because the distributing system is also capable of causing serious modifications in the results obtained. However, the greatest opportunities for energy loss generally occur at the power plant, and it is at that point that the greatest effort must be made to hold up the efficiency of the system as a whole.

When a power plant is once installed, its maximum possible thermal efficiency is set. That is, with the combination of apparatus available it is possible to obtain a certain maximum thermal efficiency. The constant effort of the operating crew should be centered about attaining efficiencies as near this value as is economically possible. In this effort it is generally found necessary to concentrate most of the attention on the boiler room. This results from the fact that the efficiency of the generating end is practically fixed by the design of machinery installed. So long as steam at the proper pressure and temperature is delivered to this machinery, it will operate at a certain definite efficiency unless it is allowed to depreciate in an unwarranted manner. It is true that slight variations can be caused by incorrect use of auxiliaries with consequent imperfect heat balance, and that variations of similar sort can be caused by imperfect operation of condensing equipment, but in the end the generating plant tends to maintain efficiencies of certain orders determined only by its design and the loading schedule. On the other hand, the boiler plant has no characteristic, self-maintained efficiency. It is much more independent of initial design and much more dependent upon operating skill for the attainment and maintenance of high efficiency.

Thermal Efficiency Not the Only Point Involved

Before taking up a consideration of boiler-plant efficiency, it is desirable to point out that thermal efficiency is not the only consideration involved. What is really wanted is the highest possible commercial efficiency. This means that the sum of charges, capital, maintenance, the fuel, labor, and numerous small additional items, should be as small as possible per unit of product if that result is consistent with all other considerations entering the problem. Briefly, then, we may consider the boiler-room problem as the obtaining of a sort of compromise of numerous considerations yielding a result which commercially is the best available solution under given circumstances. The compromise starts with the choice of apparatus and its installation and continues during the operation of the plant. It is convenient to begin the study of this problem with the efficiency curve of a boiler and furnace combination. In all cases this is probably a domed curve, as shown in Fig. 2, the height of the curve and its shape varying somewhat with the character of grate or stoker, the kind of fuel used and the type of boiler. With modern stokers it is not at all difficult to drive boilers to 400 per cent. of normal rating if the installation is planned for that purpose and it is possible to shift the dome of the efficiency curve to the right or left, within certain limits, by varying the ratio of stoker capacity to area of heating surface. It is obviously possible to obtain a given quantity of steam from a certain number of boilers operating at rating, or from half that number operating at double rating, or one-quarter that number operating at four times the normal rating. As the number of boilers installed for generating a given quantity of steam decreases, the capital charges also decrease, but if the boilers are driven at a point to the right of the dome of the efficiency curve, decreased capital charges are more or less balanced by increased fuel charges and in extreme cases by increased maintenance charges as well. In a general way expensive fuel and high load factor warrant the installation of ample boiler capacity with generously proportioned stokers, while low load factors and cheap fuel dictate exactly the opposite solution. In any case the designing engineer must base his decision upon the relative costs of capital and fuel and the effect which load factor will have upon these two opposing items.

The installation of an economizer depends upon exactly the same sort of an analysis. Its presence makes possible the attainment of greater thermal efficiency, but entails increased capital, maintenance and operating charges. The higher the load factor the greater the chance of an economizer being economically justified. Also, the greater the stoker capacity per square foot of boiler heating surface the more likely is an economizer to show a financial saving. From the foregoing it is obvious that no comprehensive statement as to best boiler capacity can be made. A plant required to carry an extraordinarily high peak for a few hours each year and to operate at very much lower loads during the remainder of the time or actually to stand idle, will obviously call for the installation of the minimum boiler surface, and provision for operating at a very high percentage of rating. A plant operating throughout the year at a constant load should obviously be designed in such a way that the boiler equipment operates at that load which corresponds to the dome of the efficiency curve or at a load very near that. Between these two extremes lie almost an infinite number of possible solutions, each correct for one set of conditions.

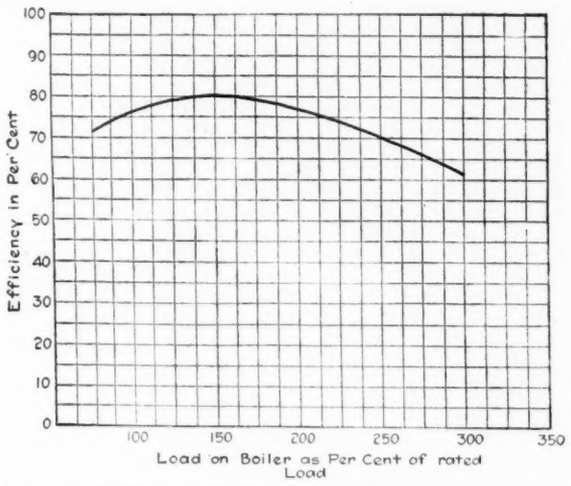


FIG. 2. OVER-ALL THERMAL EFFICIENCY OF BOILER

Assuming that the designing engineer has proportioned the various parts correctly, it falls upon the operating engineer to so operate those parts as to obtain the best results of which they are capable; that is, so as to obtain the required amount of steam with the maximum expenditure of money for fuel, water, firebrick and other supplies, repair parts and labor. Again, the solution of the problem differs with the conditions and no universal rule can be given. Following is an example of one typical plant considered at length. The generating units are operated as nearly as possible at the load at which they have their minimum water rate, and the boilers are so proportioned that under these conditions they operate under the loading which experience has shown to correspond approximately with the location of the dome of the efficiency curve, and the boiler can follow the turbines through moderate decreases or increases of load without getting far from the dome of the efficiency curve, and they can follow the turbine down to very low loads without requiring banking of the fires with its consequent disturbance of firing conditions. Moreover, they are capable of supplying steam for the maximum possible turbine load without reaching so near to limiting conditions as to seriously affect efficiency or maintenance. Under normal operating conditions the life of stokers, firebrick and tubes is such as to reduce maintenance charges to a minimum. Labor in the handling of coal is reduced to a minimum by the following methods: Coal, received in bottom-dump railroad cars, is dropped into the track hoppers, raised by conveyors to the crushers, discharged from the crushers into a conveyor which carries it to the top of the boiler house, discharging it into bunkers, from which it gravitates through spouts to the stokers. The refuse remaining after burning the coal is dumped periodically into full-size railroad cars from ash hoppers, and labor is thus also reduced to a minimum. Firing in this plant is regarded more as

an art than as labor. The firemen are chosen for their mental capacity rather than for their muscular development and are paid accordingly. They are assisted in the acquisition of knowledge and development of skill by working under direct supervision. Each boiler is supplied with an instrument board on which are such indicating and recording instruments as experience has shown to be desirable in assisting the firemen in utilizing coal to the best advantage.

The operator's task is really the generation of a given quantity of steam at a given pressure with the minimum consumption of coal. The pressure is indicated by pressure gages, and the quantity of steam is indicated, recorded and integrated by a flow meter. In order to make the required amount of steam the proper amount of coal must be introduced and burned, by varying the speed of the stokers guided by the indications of tachometers reading both revolutions of stoker per hour and thousands of pounds of coal per hour.

With the proper amount of coal entering the furnace the operator must next be able to regulate the air pressure under the fire to burn it at the proper rate. This is done by varying the speed of the motor-driven blowers so that the desired pressure is maintained at two characteristic points as indicated by two vertical pressure indicators.

Control of Drafts

The next part of the problem is the removal of the products of combustion and the control of furnace drafts by proper control of the damper. An inclined-type draft gage graduated to read to hundredths of an inch indicates the draft at a particular critical point in the setting, and the operator controls the position of the dampers to maintain a predetermined draft at this point. The degree of the operator's success in properly coördinating the various controls is partly indicated by the record made by the CO_2 machine. This is not, however, a complete measure of success as it is possible to get poor results despite a normal CO_2 indication. For further guidance the fireman inspects the fire through doors in the setting and may further check his results by two inclined-tube draft gages that indicate the draft at the two dampers respectively and, taken in conjunction with the draft gage previously mentioned, serve to indicate the condition of baffles and gas passages as well as the character of the firing. As a further indication of the degree of success attained, the fireman also has the readings of a recording thermometer, which gives him average temperatures of gases discharged from the boiler. Manual labor is reduced to the mere handling of controllers and switches, and it is thus made possible to employ men with the mental capacity requisite to a proper appreciation of the readings of the instruments and the furnace conditions which they indicate.

The outside surfaces of all boilers in this plant are cleaned by means of mechanical soot blowers. Flue-gas temperatures are used to check the cleanliness of the tube surfaces, and cleaning is done as often as these temperatures indicate it to be necessary.

The inner, or water, surfaces of the tubes are kept clean by feeding only water that contains no mud or scale-forming material. This is accomplished by reducing to a minimum the quantity of makeup water and the distilling of all makeup so that it enters the system as vapor, leaving the mud and other undesirable materials in the evaporator. The makeup water averages in the neighborhood of 1 per cent. of the water evaporated, and little difficulty is experienced in distilling so small a quantity. The results of the use of such water are of three sorts. First, the boilers do not require frequent internal cleaning. In this way the boiler-room labor and the number of spare boilers required is reduced. Second, as there is practically no scale in the tubes, there are practically no tube failures and all expenses incident to such occurrences are avoided. Third, as no mud collects in the boilers, it is not necessary to blow them down at frequent intervals and heat is thus conserved and makeup water is reduced in quantity.

Finally, as a check on the performance of the operating crew, careful running records are kept and the efficiency and costs of operation are calculated and distributed to the proper individuals at frequent and regular intervals. All coal is weighed into the plant, sampled and analyzed, water is metered into the boilers and the steam is measured as it issues from the boilers. The pressures and temperatures are also recorded continuously and an efficiency figure is determined for each period of operation. The success of this general method is shown by the fact that the boiler equipment of this plant averages in regular operation a thermal efficiency within about 5 to 7 per cent. of that which it is capable of attaining under best conditions at best load.

Guards on Engines

Flywheels should be guarded as follows:

Where the guard is not less than 15 in. from the wheel, by a railing the top rail of which is at least 42 in. from the floor, with an intermediate rail midway between top rail and floor and a toe-board at least 4 in. high at the base of the railing.

Where guard is less than 15 in. from the wheel, it should be not less than 5 ft. high (unless wheel is less than 5 ft. in height, in which event guard need not extend above wheel) and should be a solid guard or a mesh guard with openings not greater than 1½ in. in any direction.

Flywheel guards should be carried over the bearings at the same relative height as the guard on the floor and should be of the same construction as to size of openings in guard.

A disk guard of metal or fiber is considered safe on balance wheels not more than 5 ft. in diameter, where they do not extend through the floor. Such disk guards should be so attached to the wheel as to protect the spokes. When space is left between edge of disk and rim of wheel, to facilitate turning wheel over, it should not exceed 2½ in. in width. When disk guard is used see that keys or other projections in hub or rim of wheel are guarded.

No door or gate should be allowed in flywheel protection, except on gas or oil engines where such provision may be necessary.

Crankshafts, connecting-rods and tail-rods should be inclosed by sheet metal or mesh fabric in such a way as to prevent accidental contact with them, or they should be protected by a standard railing at least 15 in. and not more than 20 in. from the moving parts. Any points of railings coming within 15 in. of a moving part should be covered with sheet metal or mesh fabric.

In some instances oil shields are so arranged as to inclose these parts, making additional guards unnecessary.

Care should be taken to guard all other revolving or reciprocating parts or shearing motions where accidental contact may cause injury.

Main bearings which cannot be reached readily from the floor should be equipped with standard stairs having safety treads and railings on side opposite flywheel.

All ladders and stairs on engines should be railed and all staging 6 ft. or more above the floor should have a railing with a toe-board at least 4 in. high at the base of the railing.

When the engine bed is used as a walk, it should be equipped with a proper railing and toe-board.—*National Safety Council.*

Lubrication of Wire Rope

It is pointed out in *Lubrication* that a very important detail in the lubrication of wire ropes is the application of the lubricant. Various methods have been employed, and in adopting any one method or combination of methods the particular mode chosen must be dictated by the specific problem encountered. On inclined and horizontal ropes, where operating speeds permit, operators very often pour the lubricant on the rope, the excess being caught in a pail, which serves the double purpose of container and overflow vessel. It has been found excellent practice to paint the lubricant on with a brush, catching the surplus, as before, in a pail. Good results have been obtained by providing each rope with a trough through which the rope is compelled to pass by making it run under a wheel mounted on the trough. Another device consists of a barrel fitted with steam coils, to insure a proper heating of the product, and a valve and short piping arrangement for furnishing a continuous flow of the lubricant to the rope, suitable means being provided for wiping the cable and conserving the excess dressing. Engineers report good service obtained by pouring the dressing on the winding drums. Others report that they have obtained best results by providing each rope with a split box of some 25 lb. capacity into which compounds can be poured while hot and through which the rope passes in operation.

Call for Overseas Mechanics

The call for national service has been sounded for mechanics, superintendents and foremen in the mechanical trades to qualify as officers in the Ordnance Department of the United States Army.

In order that full recognition shall be given to the men who have acquired this highly mechanical knowledge, and know how to apply it and direct men intelligently, the commissions of captain, first lieutenant and second lieutenant will be granted to successful applicants with corresponding pay and privileges.

The Ordnance Officers' Examining Board will hold examinations in the following cities: Cleveland, Aug. 19 and 20; Detroit, Aug. 21 and 22; Chicago, Aug. 23 and 24; St. Paul, Aug. 26; Minneapolis, Aug. 27; Des Moines, Aug. 28; St. Louis Aug. 29 and 30; Indianapolis, Aug. 31.

These officers are placed in command of the mechanical crews stationed behind the lines for quick repair of tractors, motors, guns and other fighting ordnance equipment, so that the advance of the Army will not be held up. These units are of inestimable value in salvaging broken-down pieces and sending them back into action. These officers will be assigned to Division Ammunition Trains, Mobile Ordnance Repair Shops and Motorized Field Artillery Regiments.

All applicants must be over draft age and under 40 years.

They must be highly skilled mechanics of shop foremen or manager type and experience, men who have had considerable practical automobile-repair experience and who can efficiently handle men in the shops as their actual superiors, instructing them what and how work should be done. It is necessary that they should have had actual machine-shop experience.

Graduates of mechanical engineering schools without shop experience are not suitable, nor are men whose previous experience covers operation only, as they are unable to assimilate the training given by the Ordnance Department, or to instruct their subordinates who make the actual repairs. It is not necessary that applicants be college graduates or members of engineering societies.

They should be practical men who understand the construction and maintenance of automobiles and tractors and know such problems as how to time motors, how to adjust carburetors, the causes of preignition, the setting of magnetos, how bearing should fit, and important points regarding key fitting for taper shafts, etc.

Applications when received will be considered on their merits, and arrangements will be made to immediately give personal consideration to such applicants, as from their application, it is deemed desirable to personally examine.

All men desiring to apply and living in or near one of these cities should apply for the Preliminary Application Blank and instructions to the office of the Military Training Camps Association, stationed in each of the cities noted. Applicants living in other districts should write to C. W. Jones, War Service Exchange, 596 State, War and Navy Building, Washington, stating training and experience in mechanical lines.

Ordnance Department Needs More Men

Thousands of men in dozens of big manufacturing plants in the metropolitan district alone are working at top speed for the United States ordnance department. Their product includes everything from harness to motors—from gun carriages to large caliber shells. The rapidity with which this gigantic undertaking was organized and put under way, and the total output now on the other side, and going over, is remarkable.

When it is realized the French fired approximately 60,000,000 shells during the six-months' siege of Verdun, and that this represented some 1,800,000 tons of steel—to say nothing of 9,000,000 tons of coal necessary to make and transport those shells to the front—some idea may be gained of the magnitude of the ordnance production necessary in this war, says the Boston *News Bureau*. War with Spain cost the United States $200,000,000. We are already spending nearly this amount every five days in the present conflict.

During the entire Franco-Prussian War, Germany used 650,000 shells. There have been many days since the beginning of the great drive of Mar. 21 last when Germany, in less than two hours, used this number of shells. It is not at all unusual to fire as many as ten large shells a second at a single point. At five shells a ton of coal and 20 shells a ton of steel, this represents 7200 tons of coal and 1800 tons of steel an hour. Necessity for uninterrupted production on an increased basis is very pressing.

To accomplish necessary results in the ordnance department, Washington has issued call after call for the biggest men in the country in their respective branches of industry. Response has been spontaneous from all parts of the United States.

But the Government needs still more experts in plants of this district. C. V. Meserole, special representative in New York of the ordnance department, has issued a call for production men, experienced in machine shop and erection, ammunition, explosives, loading, small arm and gage work. These are among the best paying positions in the ordnance department, and require men capable of visiting shops, conferring with managers and speeding up work whenever opportunity presents itself. Selling experience, ability to direct large forces of men and personality are important qualifications.

Less Bituminous Mined

Production of bituminous for the week ended Aug. 3 was 12,422,000 tons, a falling off of 396,000 from the previous week. This output compares with 10,859,000 tons for the corresponding week of 1917. Car shortage, according to the Geological Survey, was responsible to a great extent for the decline which marked the third successive week of decreasing production.

Average production per working day was 2,070,000 tons, against 2,137,000 during the preceding week and 1,810,000 for the corresponding week of 1917. Shipments show a big falling off in all regions except Tennessee, Kentucky, Iowa, Texas and the southwest states. Anthracite shipments as reported by leading anthracite carriers were 39,632 cars, a falling off of 1310 from the previous week.

Measuring the Volume of Rivers

The quantity of water that ordinarily flows in a stream and the quantities that flow at times of flood and at times of low water are of vital importance to the engineer who may want to utilize the water for power or for irrigation or who desires to study the value of the stream for navigation, as well as to the man who owns land along the stream and who wants to sell his water-power rights. For this reason the Government, in 1888, began to measure the flow of streams in the United States, and since 1895 the bills passed by Congress appropriating money for the work of the Geological Survey have carried an item for "gaging streams."

The results of this stream-gaging work in the drainage basins of the country are issued yearly in water-supply papers published by the United States Geological Survey, Department of the Interior. From these papers the engineer may ascertain not only the volume of the stream and its fluctuations during the year and from year to year, but also its mean and surface velocities, its mean depth and the water power which may be developed on it.

These reports include descriptions of the stations at which the measurements were made and tables giving the daily and monthly discharge of the streams. An appendix contains lists showing the gaging stations maintained in the area covered and the publications relating to their water resources.

Water-Supply Papers 406, 434 and 437 may be obtained on application to the Director, United States Geological Survey, Washington, D. C.

DELEGATES, SUPPLYMEN AND GUESTS AT THE ANNUAL CONV

Convention of the Universal Craftsmen at Detroit

The sixteenth annual convention of the Universal Craftsmen Council of Engineers was held in Detroit, Mich., Aug. 5 to 9, with headquarters at the Hotel Statler. The several sessions of the convention were held in the assembly room of the Park Building, located a short distance from the headquarters. There were more than 150 delegates present, and many important measures conducive to the welfare of the organization were discussed and passed upon. The main hall of the Park Academy Building was tastefully decorated and arranged for the use of the supplymen in the display of power-plant equipment and engine-room supplies. There were thirty-six firms represented.

The official opening exercises of the convention took place on Tuesday morning at ten o'clock in the exposition hall. Austin Secrist, chairman of the local committee, was glad to see so large an attendance of delegates and ladies and assured the visitors that everything possible would be done to make their stay pleasant. He introduced William T. Dust, commissioner of parks, representing the mayor, who cordially welcomed the convention to Detroit. Senator A. P. Flowers told of the beauties of Detroit, and enlarged upon the wonderful manufacturing industries of the city and of the immensely important work the plants were doing at the present time for the Government. Herbert E. Terry, grand worthy chief, responded in a fitting manner for the engineers. After the address of Grand Chaplain P. H. Early the ceremonies came to a close and an adjournment was taken until one o'clock.

On Wednesday afternoon there was an auto ride through Belle Isle and Riverview Parks and at eight o'clock in the evening a lecture was given by John Trix in the exposition hall.

On Thursday afternoon there was a boat trip to Bob-Lo, and a lecture in the evening by Austin Secrist, in the exposition hall, after which light refreshments were served in the assembly rooms.

On Friday afternoon the annual memorial services were held. A moonlight excursion on the Detroit River in the evening brought the entertainment features of the convention to a close.

At the final session on Friday morning the following grand officers were duly elected and installed: Frank M. Townsend, chief, Grand Rapids, Mich.; Frank Conroyd, assistant chief, Chicago, Ill.; Thomas H. Jones, secretary, Washington, D. C.; John L. O'Brien, treasurer, Chicago, Ill.; Andrew Benner, warden, Columbus, Ohio; W. G. Warfield, guard, Newark, N. J.; H. Burton, Cleveland, Ohio., I. Patton, Buffalo, N. Y., George Brown, Pittsburgh, Penn., trustees. Thomas O. Organ was elected chairman of the educational board. Newark, N. J., was selected as the place of the next convention, to be held in August, 1919.

Seattle Applies for Approval of Light and Power Bonds

The City of Seattle for thirteen years has been operating a municipal light and power plant located at Cedar Falls on Cedar River. The original plant in 1905 delivered but 3200 hp. within the city limits. This plant has depended on, and is now depending on, a wooden dam constructed at the outlet of Cedar Lake and has about 16,000 ft. of wooden penstocks between the dam and the power plant. In 1908 the city added to the plant, bringing it up to 13,860 horsepower.

Because of the danger of accident to the wooden dam and penstocks a standby or emergency steam plant was built within the city limits and put in service in 1914, giving 27,190 hp. at that time. As demands continued to increase rapidly, the city began the construction of a masonry dam on Cedar River to render available 27,500 hp. When this was completed, in 1915, a part of the bank of the basin was found to be porous and it became necessary to seal it before the dam could be used. On account of the location of the existing wooden penstocks, they had to be disconnected during the sealing process and so the city's hydroelectric plant was shut down, throwing the load on the standby plant, to which a unit was added to take care of conditions fast becoming acute. This unit was put in operation in June of this year and brought the total power up to 40,250 hp., of which 27,000 hp. is obtained from steam by burning oil in plants intended for emergency service, but which are now being operated continuously under heavy load.

The records show that the normal demand for power increased about 1000 hp. per month from 1905 to 1918, and during 1918 this average has been greatly exceeded. Before the city could carry out its plan of extending its light and power system, the United States entered the war, thus delaying the work that was imperative even before the war began. Desiring to coöperate with the Federal policy in carrying on the war, Seattle voluntarily applied to the Capital Issues Committee, Washington, D. C., for its approval of a bond issue of $5,500,000 to carry out the plan. This matter was referred to the subcommittee at San Francisco, where the question was raised as to the necessity of the issue at this time.

To verify the correctness of the conclusions at which the city had already arrived, a careful investigation was again made by the city, through its engineer and its superintendent of lighting, assisted by a former city engineer. In addition, the city engineer of San Francisco was employed

CONVENTION OF THE UNIVERSAL CRAFTSMEN COUNCIL OF ENGINEERS

to make a personal investigation and to report on the urgency and necessity for further electric-power development at Seattle. The unanimous opinion of these four engineers was that the city should at once undertake the development of a large amount of additional hydro-electric power.

Accordingly, a committee consisting of Ole Hansen, Mayor of Seattle; C. B. Fitzgerald, chairman of the finance committee; Hugh M. Caldwell, corporation counsel, and R. H. Thomson appeared before the Capital Issues Committee at Washington, presented a detailed report of the conditions as found by the engineers, and argued in favor of the approval of a bond issue of $5,500,000 to construct a water-power plant on the Skagit River, so as to meet the rapidly increasing demands for power.

To Render Boiler Settings Air-Tight

For sealing small cracks in the boiler setting a good paint can be made as follows: 10 lb. Trinidad asphalt; 1 gal. benzine; 7.5 lb. portland cement; 7.5 lb. mixture of 85 per cent. magnesia and 15 per cent. asbestos. Heat the asphalt to the consistency of paint. Mix the cement and magnesia-asbestos and heat in an oven to 300 deg. F. Remove the asphalt to a safe distance from the fire and mix in the benzine thoroughly; then add the cement and magnesia-asbestos compound and stir to a uniform mass. Keep the benzine away from the fire.

The paint should be applied hot with a 4-in. brush, and brushed well into the cracks. Two light coats are better than one heavy coat. Immediately after applying the last coat, cover the fresh paint with a coating of sand by throwing it forcibly against the painted surface.

One application should maintain an air-tight surface for a year.—*Iron Age.*

Large Water-tube Boilers

Up to now the largest steam boilers in use in the Manchester (England) Corporation power stations at Stuart St., have been the Babcock marine type, capable of giving 60,000 lb. of steam per hour "from and at." There are four of these generators, each having 312 sq.ft. of grate surface, 11,000 sq.ft. of heating surface, 5838 sq.ft. of economizer surface, and 4090 sq.ft. of superheater surface. They are each constructed as a self-contained unit, with their own chimney and induced-draft plant. In order to keep pace with the ever increasing demands for electrical energy and to make the best possible use of the restricted floor space, says *The Engineer*, a group of 24 similar boilers is being removed, and they will be replaced by four Babcock water-tube boilers which are claimed to be the largest in the kingdom. Two of them are now in process of erection. Each boiler will have 416 sq.ft. of grate 14,500 sq.ft. of heating surface, 8500 sq.ft. of economizer surface, and 5145 sq.ft. of superheater surface. These boilers are constructed for a working pressure of 225 lb. per sq. in., and are expected to give easily 100,000 lb. of steam per hour from and at when burning coal having a calorific value of 11,000 B.t.u. Each of these boilers is a self-contained unit, with superheater, independent chimney, and induced and forced draft. Each has four 16 x 6½-ft. grates, and occupies a floor space 35 x 22 feet.

Plant Coal Costs Increased

For the fiscal year ended Mar. 18, 1918, the cost of 8141.5 tons of coal for the electric light and power plant at Holland, Mich., was $43,936.75, or $5.39 per ton. The cost of stocking a surplus during the summer, purchasing expenses and freight tax caused an additional expense of $1044.65, which raised the average cost per ton for the year to $5.52. Last year's average cost per ton was $3.33, the increase for the year being over 60 per cent. The importance of such an increase can be better appreciated when it is stated that the total coal cost of $43,936.75 equals approximately one-half of the total operating revenue of the station, which was $89,387.51. The total output from the plant during this period was 2,817,913 kw.-hr. The plant operated at an annual load factor of 30.12. The price per ton paid during the year ranged from $3.40 to $7.10.

Forced-draft apparatus cannot supply enough air through level fuel bed to insure complete combustion, and additional air must always be introduced over the fire in such a manner that it will mix with the combustible gases; otherwise a large percentage will escape unburned. This does not, however, make desirable the admission of air through holes in fires and leaks in the furnace setting. The ideal way to supply additional air over the fuel bed is to introduce it as close to the fuel bed and in as large a number of small streams as possible. The nearer the air is introduced to the surface of the fuel bed the more combustion space is utilized for mixing and burning the mixture. As a general statement, about one-half of the 15 lb. of air used to burn 1 lb. of coal is supplied through the fuel bed; the other half must be supplied over the fuel bed.—U. S. Bureau of Mines Technical Paper 137, 1916.

The municipal authorities at Bristol, England, have decided to extend the electrical plant by providing an additional 6000-kw. turbo-alternator and four water-tube boilers. These extensions are necessary on account of the increased demand for electricity. In regard to the scarcity of coal, it has been pointed out that, while 18.75 lb. of coal was consumed in 1895 to produce a kilowatt-hour of electricity, in 1917 the quantity was reduced to 4.938 lb. The coal consumption per kilowatt-hour has been cut to approximately a quarter what it was 20 years ago. While in 1917 only 56,000 tons of coal were consumed, at the former rate of consumption 200,000 tons would have been used.—*Commerce Reports.*

New Construction

PROPOSED WORK

Conn., Hartford—The H. Southern Eng. Co., 11 Laurel St., plans to install a steam heating system, boiler, etc., in the proposed 2 story laboratory.

N. Y., Elmira—The Morrow Manufacturing Co., South Main St., will install a steam heating system in the proposed 2 story, 65 x 130 ft. factory. Total cost, $30,000. Mills, Rhines, Bellman and Nordoff, 1234 Ohio Bldg., Toledo, Ohio, Arch.

N. Y., Lancaster—The Nutrio Creamery Co., c/o J. Roche, White Bldg., Buffalo, is in the market for belting, motors, shafting, etc., in connection with the proposed creamery. A steam heating system will be installed in same.

N. Y., Brooklyn—The Modern Toy Co., 171 Belmont Ave., will receive bids about Sept. 15 for the installation of a steam heating system in its proposed 1 story, 96 x 150 ft. factory on Junian St. and Riverdale Ave. Total cost, $20,000. Cohn Bros., 361 Stone Ave., Arch.

N. Y., Syracuse—Roberts & Schuyler, 614 City Bank Bldg., will install a steam heating plant in their proposed 2 story, 50 x 130 ft. garage and show-room to be erected at 647 South Warren St.

N. Y., Utica—The Mohawk Valley Cap Co., 203 Park Ave., will soon receive bids for the installation of power piping, pumps, shafting, belting, etc., in its proposed 4 story, 70 x 100 ft. knitting mill on Park Ave. Total cost, $50,000.

N. J., Newark—The Ruth Realty Co., 31 Runyon St., plans to install a steam heating plant and boilers in the proposed 1 story, 60 x 80 ft. factory at 30-32 Brandford St. D. Ruth, Pres.

Penn., Philadelphia—The Lutz Co., Inc., 31st and Mays Ferry Ave., plans to install a low pressure steam heating system in its proposed 3 story, 40 x 55 ft. office building on Morris and Bambrey Sts. Total estimated cost, $60,000. Peuckert & Wunder, 310 Chestnut St., Arch.

W. Va., Fairmont—City is in the market for a new electric pump and transformers, cost, $13,200; also base connections and installation, $15,000. Smith and Barnes, City Commissioners.

Fla., Monticello—City plans an election to vote on $17,500 bonds to build an electric lighting and power plant. J. M. Johnson, Mayor.

Fla., Pensacola—The Bureau of Yards and Docks, Navy Dept., Wash., D. C., plans to install a heating system in officers' quarters, mess and recreation halls. Estimated cost, $4000.

Ohio, Bellaire—The Captina Coal Co. plans to electrify its mine and install a motor in same. Estimated cost, $20,000. W. Rennie, Supt. A. A. Minder, R. Mathice, J. F. Du Bois, and others, interested.

Ohio, Cleveland—The Buckeye Brass Co. is receiving bids for the installation of a steam heating system in the proposed 1 story, 70 x 140 ft. foundry.

Ohio, Cleveland—City will receive bids in Sept. for the erection of a 1 story, brick, steel and concrete boiler house. Estimated cost, $50,000. F. A. Betz, City Hall, Arch.

Ohio, Cleveland—The Cleveland Punch and Shear Co., 3929 St. Clair Ave., plans to install a steam heating system in its proposed machine shop. Total estimated cost, $35,000. C. W. Courtney, 509 Leader News Bldg., Engr.

Ohio, Cleveland—The National Acme Manufacturing Co., Stanton and East 75th St., will soon award the contract for the installation of a steam heating system in the proposed 1 story, 121 x 170 ft. foundry.

Ohio, Cleveland—The G. S. Rider Co., Engr., Century Bldg., is receiving bids for the installation of a steam heating system, complete electric power equipment, etc., in the proposed 6 story factory of the Cleveland Twist Drill Co., 1242 East 49th St.

Ohio, Cleveland—The Vlebeck Tool Co., 10,709 Quincy Ave. plans to install a steam heating system in the proposed 3 story, 50 x 70 ft. factory. Total estimated cost, $60,000.

Ohio, Hamilton—The Mosler Safe and Lock Co., Grand Blvd., plans to install a steam heating system in the proposed 1 story, 50 x 350 ft. and 50 x 550 ft. factory buildings. Total estimated cost, $300,000.

Ohio, Norwalk—City plans to issue $25,000 bonds to purchase a 500 kw. generator for its lighting plant.

N. M., Lordsburg—Messrs McKnight, Hoops and Prescott are in the market for an extra 25 hp. gas or oil engine, etc., for installation in the proposed 50 ton mill to be erected 8 mi. south of here. B. Prescott, Supt.

Calif., Ventura—W. F. McClure, State Engr., Forum Bldg., Sacramento, will receive bids for the installation of heating and plumbing system in the proposed state school for girls to be erected here.

Calif., Weimer—The Joint Tuberculosis Society, Sacramento, will soon award the contract for the installation of a heating system in the proposed 1- and 2-story, 20 x 40 and 60 x 100 ft. hospital near here. Total cost, $60,000. R. A. Herold, Forum Bldg., Sacramento, Arch.

PRICES AND CONTRACTS AWARDED

N. Y., Buffalo—The Air Reduction Sales Co., Inc., 584 Carroll St., has awarded the contract for the erection of a 50 x 150 ft. factory on Grant St. near the New York Central tracks, to the Hydro Constr. Co., Mutual Life Bldg. Estimated cost, $25,000. A steam heating and electric lighting system will be installed in same.

N. Y., Buffalo—The National Lamp Works, Illuminating Bldg., Cleveland, Ohio, has awarded the contract for the erection of a 3-story, power house and factory on Fillmore Ave., here, to Huntley & Derdenger, Electric Bldg. Estimated cost, $200,000. Noted Aug. 6.

N. Y., Brooklyn—The Bureau of Yards and Docks, Navy Dept., Wash., D. C., has awarded the contract for the erection of a swimming pool and the installation of heating apparatus in the 52nd St. Armory, to the P. F. Fox Constr. Co., 154 Nassau St., New York City. Estimated cost, $26,000—60 days.

N. Y., New York—The Bureau of Yards and Docks, Navy Dept., Wash., D. C., received bids for the installation of a heating system in the structural shop (work complete), from the Enterprise Steam and Hot Water Heating Co., 600 North Howard St., Baltimore, Md., $69,960; Gillis & Gehagen, 537 West Bway., $71,335—120 days; alternate bid, $69,335—110 days; E. Rutzler Co., 404 East 49th St., $72,987—90 days. Noted July 16.

D. C., Wash.—The Bureau of Supplies and Accounts, Navy Dept., received low bids for equipment as follows:

(Item 1)—1 motor generator, booster set, 150-kw. DC.; Schedule No. 5128¾, Class 656, delivery Navy Yard, Portsmouth, N. H., from Burke Electric Co., 12th and Cranberry St., Erie, Penn., $4900; Westinghouse Electric Co., Hibbs Bldg., Wash., D. C., $6415; Allis Chalmer Manufacturing Co., West Allis St., Milwaukee, Wis., $6420; General Electric Co., River Rd., Schenectady, N. Y., $5510.

(Item 3)—1 induction motor, 15 hp., 3-phase, 60-cycle, 220-volt, constant speed; Schedule No. 5096½, Class 766, delivery Submarine Base, New London, Conn., from Crocker Wheeler Co., Ampere, N. J., $370; D. Nast Machine Co., Bourse Bldg., Philadelphia, Penn., $368; Reliance Electric and Eng. Co., Munsey Bldg., Wash., D. C., $296; Manning, Maxwell and Moore, 119 West 40th St., New York City, $374; Kemp Machine Co., 223 North Calvert St., Baltimore, Md., $310.

(Item 1)—1 motor with starting devices; Schedule 5238¼, Class 833, delivery Philadelphia, Penn., from Bell Electric Motor Co., Garwood, N. J., $187; Carroll Electric Co., 714 12th St., Wash., D. C., $217; Century Electric Co., 19th and Pine Sts., St. Louis, Mo., $250; Mechanical Appliance Co., 133 Stewart St., Milwaukee, Wis., $229.

D. C., Wash.—The Bureau of Yards and Docks, Navy Dept., Wash., D. C., received bid building a power house at the Naval Ammunition Depot, St. Julien Creek, Va., (1) price and time for the work complete, using common brick, pitch and gravel or slag; (2) amount and time to be added or deducted from (1) if air lock brick and tile are used instead of common brick in all walls; (3) amount and time added or deducted from (1) if asphalt and gravel for slag roofing is used instead of pitch and gravel or slag; (4) amount and time added or deducted from (1) if hollow terra cotta wall brick and tile are used instead of common brick in all walls; (5) amount and time added or deducted from (1) if asphalt impregnated asbestos roofing is substituted for pitch and gravel or slag, from Johansen & Kiernen, 205 Citizens Bank Bldg., Norfolk, Va., (1) $12,963—120 days; (2) add $450; (3) add $80; (4) add $400; (5) add $115.

Okla., Tulsa—The First National Bank has awarded the contract for plumbing, heating and ventilating, to the MacMahon Co., 1329 Oak St., Kansas City, Mo. Total estimated cost, $90,000.

THE COAL MARKET

Boston—Current quotations per gross ton f.o.b. mines are as follows:

ANTHRACITE

	Circular Current
Buckwheat	$3.40
Rice	2.90
Boiler	2.65
Barley	2.40

All-rail rate to Boston is $2.86.

BITUMINOUS

Bituminous, $8 to $8.75.

Pocahontas and New River, f.o.b. Boston $8.35 to $8.90.

New York—Current quotations per gross ton f.o.b. Tidewater at the lower ports* are as follows:

	Circular	Individual
Pea	$5.20	$5.95
Buckwheat	5.15	5.90
Rice	4.65	5.10
Barley	4.15	4.30
Boiler	4.60	....
Broken	6.75	7.50
Egg	6.35	7.10
Stove	6.60	7.35
Chestnut	6.70	7.45

Quotations for domestic coals at the upper ports are 5c. higher on account of the difference in freight rates. Prices for buckwheat, rice, barley and boiler are not fixed by the Government.

BITUMINOUS

Current quotations, gross tons, based on Government prices at the mines, net ton; f.o.b. Tidewater, at the lower ports, are as follows:

	Mine Gross	F.O.B. N.Y. Gross
Central Pennsylvania (Mine run, Prepared or Slack)	$3.30	$5.45
Upper Potomac, Cumberland & Piedmont Fields:		
Run of Mine	3.08	5.23
Prepared	3.36	5.51
Slack	2.80	4.95

Quotations at the upper ports are 5c. higher on account of the difference in freight rates.

The foregoing prices ar exclusive of the 3 per cent. war freight tax on both anthracite and bituminous.

*The lower ports are: Elizabethport, Port Johnson, Port Reading, Perth Amboy and South Amboy. The upper ports are: Port Liberty, Hoboken, Weehawken, Edgewater or Cliffside and Guttenberg. St. George is in between and sometimes a special boat rate is made. Some bituminous is shipped from Port Liberty. The ratte to the upper ports is 5c. higher than to the lower ports.

Philadelphia—Prices per gross ton f.o.b. cars at mines for line shipment and f.o.b. Port Richmond for tide shipment are as follows:

	Line		Tide	
	Current	One Yr. Ago	Current	One Yr. Ago
Pea	$3.45	$3.10	$4.60	$4.00
Barley	2.40	1.90	3.30	2.55
Buckwheat	3.40	2.90	4.45	3.80
Rice	2.90	2.40	3.80	3.40
Boiler	2.70	2.20	3.70	3.30

Chicago—Steam coal prices f.o.b. mines:

Illinois Coals	Southern Illinois	Northern Illinois
Prepared sizes	$2.55—2.70	$3.25—3.40
Mine-run	2.35—2.50	3.00—3.15
Screenings	2.05—2.20	2.75—2.90

St. Louis—Prices per net ton f.o.b. mines are as follows:

	Williamson and Franklin Counties	Mt. Olive & Staunton	Standard
6-in. lump	$2.55-2.70	$2.55-2.70	$2.40@2.70
2-in. lump	2.55-2.70	2.55-2.70	2.40@2.70
Steam egg	....	....	2.40@2.70
Mine-run	2.35-2.50	2.35-2.50	1.85@2.00
No. 1 nut	2.35-2.50	2.55-2.70	....
2-in. screen	2.05-2.20	2.05-2.20	....
No. 5 washed	2.05-2.20	2.05-2.20	1.25@1.50

Williamson-Franklin rate to St. Louis is $1.10, other rates, $0.95.

Birmingham—Current prices per net ton f.o.b. mines are as follows:

	Mine-Run	Prepared Sizes	Slack or Screenings
Big Seam	$2.50	$2.80	$2.20
Cahaba, Black Creek, Brookwood, Blue Creek	3.20	3.45	2.80
Pratt, Jaeger, Jefferson Nickel Plate	2.70	3.00	2.40
Corona	2.75	3.10	2.40

The above are Government prices per net ton of 2000 lb. mines and include the 45c. per ton allowed by the wage agreement, less 10c. reduction which was effective May 25, as a result of the agreement with the railroad administration for furnishing fuel coal.